THE BRITISH ISLES

A Geographic and Economic Survey

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"... To the hope that one day this country of ours, which we love so much, will find dignity and greatness and peace again."

NOËL COWARD ("Cavalcade")

PREFACE TO THE FOURTH EDITION

THIS book was first published in August, 1933, nearly fifteen years after the end of the First World War but when, as explained in the Preface to the First Edition, there was still a widespread tendency to regard the pre-1914 conditions as the "normal" to which the world would in due course return. This fourth rewritten edition appears approximately nine years after the cessation of hostilities of the Second World War and we have endeavoured to avoid the error of regarding any period as "normal". We have attempted to describe things as they are, making comparisons with the past. The book has been thoroughly revised throughout and many sections completely rewritten. Once again we have enjoyed the criticism and advice of many colleagues and friends whose help, recorded in the appropriate places, is gratefully acknowledged. We are particularly indebted for assistance with the compilation of new statistical tables to R. S. Mathieson, B.Sc. (Econ.), and K. R. Sealy, M.Sc. (Econ.).

L. D. S.
S. H. B.

February, 1954.

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CHAPTER I

THE POSITION OF BRITAIN

No philosophy of British history can be entirely true which does not take account of the facts of the position of Britain.' So wrote Sir Halford Mackinder nearly half a century ago in that book *Britain and the British Seas*, which must for ever remain a landmark in the progress of thought in this country, for it marks an important stage in the resurrection from the dead of the forgotten or discredited science of geography—the study of the earth as the home of man and of the inter-relationship between man and his environment. It will be the purpose of this book to examine the natural environment afforded by the British Isles for their human inhabitants; to examine the advantages and the disadvantages of that environment; to analyse the natural resources of value to man which are proper to these islands; to see the use which the inhabitants have made of those resources, and so to lead up to a study of the present position—the capital which has been accumulated in consequence of past exploitation, and the outlook for the future in the utilisation of the resources which remain.

The philosophers of ancient Greece knew well that the earth was a sphere, and "every schoolboy knows" of the experiments of Eratosthenes by which the actual size of the sphere was measured. But the known world of the ancients occupied but a small portion of the surface of the sphere. It centred round the Mediterranean Sea. To the south it was bounded by the Sahara Desert, beyond which there were but legendary lands. On the south-east it extended to the Indian Ocean, to the east as far as Central Asia, beyond which again lay the mysterious land of Cathay known only because of the silks and porcelain brought by traders to Mediterranean Europe. On the north-western margin of the known world lay the islands of Britain. The name "Albion," which is still sometimes applied to the larger of the two islands, perpetuates the point of view of the ancients. The British Isles were approached and explored from the Continent, and it was the white chalk cliffs of Dover, facing as they do the land of Gaul, which suggested a name for the whole country. The Celtic lands of Ireland, Wales, and Scotland lay on the outermost fringe, so little known that in many of the ancient maps Scotland is represented as an island. Throughout early Christian or Medieval times the marginal or terminal position of the British Isles became accentuated as the scientific

concepts of the ancients became lost during the Dark Ages. The fantastic maps of the medieval monks show Jerusalem as the centre of a flat earth separated by the blue curtain of the sky from the celestial Jerusalem above, but again with the British Isles on the margin and doubtless near the dangerous "edge" of the world.

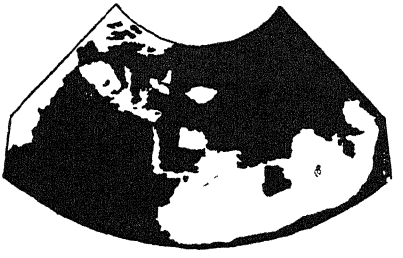


FIG. 1.—Map showing the terminal or marginal position occupied by Britain in the world as known to the ancient Greeks and medieval geographers. (*After Ptolemy*)

The year 1492 not only marks the discovery of the Americas by Columbus, but it marks the end of the dominance of the countries of the Mediterranean basin. It released the British Isles from the disadvantage of being on the fringe of world politics and placed London in the centre of the land of the globe, and the British Isles in a dominating position relative to all the world. This re-orientation was not the result of an accidental discovery. Columbus's voyage was based on a firm belief that the earth was a sphere and that it was consequently possible to sail round it. Anyone holding such a view at that time did so not only in opposition to public opinion but also in constant danger of being branded "heretical." One may wonder why the land on the far side of the Atlantic remained so long unknown to Europeans. True, the coasts of Greenland, of Labrador, and of Newfoundland were doubtless known at a much earlier date to Icelandic and Norwegian fishermen; but however attractive the fisheries might be, the character of the lands was not such as to cause enthusiastic wonder. Flowing southwards, parallel to the coast of Greenland, is a cold current bearing a constant stream of icebergs from the Arctic, and whilst a vessel may sight land, the crossing of this belt of cold water and actual landing on the shores is a matter of extreme difficulty, and climatic conditions are obviously not those to attract such attempts. The navigators of the Mediterranean, a sea which, with its great extent and its treacherous sudden storms, was no mean school for navi-

FIG. 2.—The world position of Britain to-day—the centre of the "land hemisphere"

gators, knew that when they passed through the Pillars of Hercules, or the Strait of Gibraltar, and turned southwards they were in the belt of the constant North-East Trade Winds, that would always blow them *from* known lands and would allow the venturous mariner no hope of return. Over the north of France and the south of Britain, the winds, though variable, were on the whole from the south-west; but to venture with a sailing vessel of a few tons, which could be victualled only for a limited period, merely to test the theory that one could go outwards by the north-east wind, and at some far distant point find it possible to get in the current of wind which was on the whole south-westerly, required the efforts of a dominating and fearless leader, and Columbus's own sailors nearly lost faith in their leader before land was sighted. Once the discovery had been made no one can fail to be impressed by the rapidity of events which followed—the exploration and the settlement of the American continent—and of the consequent opportunity afforded to those countries of Europe which faced the Atlantic and of which the British Isles formed one. The Mediterranean became a backwater, its commerce and its cultures decayed, and it was not until 1869–70 that the opening of the Suez Canal afforded a resuscitation of its ancient trading glory. By that time the world position of Britain was too firmly established to be shaken by the revived importance of the Mediterranean. Instead, Britain profited by yet another route to the Far East.

It may be thought that in this modern world, with all the improvements in transport and communications which have characterised the last hundred years, position would be of little importance to these islands. Such, however, is far from being the truth. An attempt has been made in Fig. 3 to show facts which can much more readily be appreciated by a glance at a globe. From the thickly populated, industrialised countries of northern Europe to the corresponding area of urban development on the far side of the Atlantic, characterised by the north-eastern United States and by the St. Lawrence Basin of Canada, the shortest route (the Great Circle route) lies across the British Isles. Presuming that the proverbial crow really does take the shortest route, that sagacious bird bound either from New York or from Montreal for any one of some fifteen or sixteen capital cities in Europe would, of necessity, have to pass over the British Isles. Actually, all ocean traffic from the ports of the northern seaboard of Continental Europe bound for North America has to make a detour to escape the British Isles and passes down the English Channel. The vessels are not taken out of their way by dropping anchor for a short time at one of the ports on the south coast of England, for example Southampton. A short time ago the importance of constructing a Channel tunnel was once again before the public eye. The scheme is interesting geographically because if the tunnel were completed a British port, such as

Liverpool, would almost automatically become the railhead of the whole European system—providing a new route for passengers and mails from Europe to America. However, where speed is important airways have replaced both seaways and railways, so that the Channel tunnel is not now likely to be undertaken. It is an interesting experiment to take a globe and a piece of string and to notice the shortest distance between Europe and various other parts of the world, and also to calculate the saving of distance—not to say the saving of time—which results by the utilisation of new routes. In any case they all serve to stress the importance of the position of Britain at present and the importance which its position is likely to maintain in the future. The modern development of trans-Atlantic

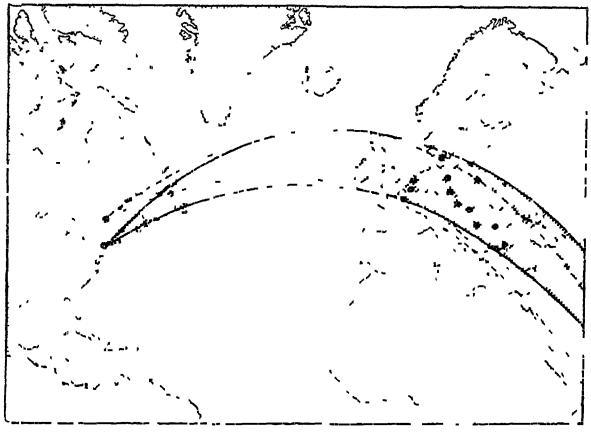


FIG. 3.—Great circle routes from Europe to North America

Within the two dark lines are the shortest routes between New York and the capitals of European states marked by dots; in each case the shortest route passes through the British Isles. The pecked line shows the same relationship for Montreal, the dotted line for the Panama Canal.

air transport has already demonstrated this. Eastward bound it is not difficult to make Montreal or New York to London in one hop and from New York London may be by-passed en route to a continental airport. The westward flight, however, is often a battle against headwinds and convenient stops are afforded by Prestwick (Ayrshire) or Shannon (near Limerick), Goose Bay (Labrador) or Gander (Newfoundland). Not infrequently surprised passengers find themselves touching down in Iceland.

Before the British Overseas Airways Corporation put into service the Comet jet-liner on the South African route in 1952 cruising speed of air liners was 200 to 300 miles per hour and any point in the world was theoretically within 48 hours of London. The Comet doubled the speed and halved the time.

The world relations of Britain reflect in many ways her world

position. If, by virtue of situation, the British Isles belong to the Continent of Europe, it is still not too much to say that the British Isles do not really belong to Europe. Viewed from the other side of the Atlantic, it seems obvious that Britain would form an essential unit in a United States of Europe or Western European Union. But the countries of Continental Europe are more "foreign" to the people of Britain than are countries overseas more distant but more closely related such as United States of America and, still more, the countries of the British Commonwealth. A few years ago Professor C. B. Fawcett carried out an interesting calculation in studying the direction of foreign mails from the British Isles. Eliminating business correspondence, the mail to America and our overseas dominions was overwhelmingly more important than that to the countries of Continental Europe. Blood ties, linguistic ties, social ties, and economic ties are with the new lands of the world.

The British Isles lie mainly within the quadrilateral formed by the two lines of longitude 0° and 10° West and the two lines of latitude 50° and 60° North. In latitude the position is roughly comparable with the almost uninhabitable lands of Labrador, to the northern part of British Columbia, and again to the almost uninhabitable lands of Sakhalin and the Kamschatka Peninsula of the coasts of Asia. The British Isles, indeed, enjoy a more favourable climate than any other land so far from the equator. To the north of the islands the sea way is open between the coasts of Iceland and of Norway to the Arctic Ocean, and a constant drift of warm water and of correspondingly warm air passes by these islands into that open channel. We have long been accustomed to refer to this drift of water as the Gulf Stream, and if purists prefer to call it the North Atlantic Drift it does not alter the fact of the significance of the phenomenon. More especially, of course, is the fact significant in winter, since the shores of the British Isles lie in the winter gulf of warmth. Apart from the advantages of world position, there are numerous advantages from the position of the British Isles more local in character. The existence of a broad Continental Shelf on which the warm waters drifting across the North Atlantic are piled up ensures not only the maximum benefit from these waters in the amelioration of climate, but it accentuates the movement of water by the tides. Thus our ports, always free from ice, are kept free from silt by the strong tidal scour, whilst the shallow seas on the Continental Shelf afford the richest fishing grounds in the world, where variety, caused by the constant movement and mixing of the waters, is the spice of life in the fish world. The English Channel, narrowing eastwards to the Strait of Dover, which is only 21 miles wide at the narrowest part, separates the south of England from France. The North Sea lies between Britain and Holland, Germany,

Denmark and Norway.[1] Whatever may be the opinion of travellers crossing the "silver streak," these separating seas are a great advantage to the islands rather than the reverse. The part they played in saving Britain from invasion during the Second World War is too well known and too recent to need emphasis. But Britain is double-faced. The ports on her southern and eastern shores face the most important and most developed parts of northern Europe. The embouchure of the Thames is opposite that of Europe's most important river, the Rhine. On the other hand, Britain's west-coast ports face the most developed parts of America. This is again symbolical of the intermediate position which Britain occupies, political, financial, and commercial, between America on the one hand and the countries of Europe on the other.

Note

In citing statistics and statements relative to the British Isles the greatest care must be taken to note the area to which reference is made in each specific case. The island of Great Britain consists of three countries—Scotland in the north, Wales in a part of the west, and England occupying the remainder. England, Scotland, and Wales have been joined under one monarch since 1603; but whilst England and Wales are usually considered together for many purposes, Scotland is distinct. Thus the Ministry of Agriculture and Fisheries refers to England and Wales but not to Scotland. Statistics and details which are published by the Ministry refer, therefore, to England and Wales only. Since 1920 Ireland has been divided into Northern Ireland and the Irish Free State (now known as the Irish Republic or Eire). Northern Ireland has a parliament of its own, but is otherwise closely united to Great Britain. But the Republic of Ireland is an independent republic. Thus "United Kingdom" used to mean the United Kingdom of Great Britain and Ireland, now it means the United Kingdom of Great Britain and Northern Ireland. The distinction is important when comparing pre-1914 with later statistics. For many purposes the Isle of Man, with a parliament (or House of Keys) of its own, is not part of the United Kingdom. Again, the laws of Great Britain do not apply to the Channel Islands unless such application is specifically laid down and approved by the islands. The following table is given for reference purposes:

	Area (sq. miles)	Population 1921	Population 1931	Population 1951
England	50,874	35,681,019	37,789,738	41,147,938
Wales	7,466	2,205,680	2,158,193	2,596,986
Scotland	30,405	4,882,497	4,842,554	5,095,969
Isle of Man	221	60,284	49,338	55,213
Channel Islands	75	90,230	93,061	157,983
Northern Ireland	5,237[1]	1,256,561[2]	—	1,369,579
Republic of Ireland	26,601[1]	2,971,992[2]	2,965,854[3]	2,958,878

[1] Excluding water areas [2] 1926. [3] 1936.

[1] Notice the shape of the North Sea. It is relatively narrow at its northern end, and the Shetland Islands lie almost half-way between the north of Scotland and the coast of Norway.

The table shows that the total area of the British Isles, including the Isle of Man and the Channel Isles, is 120,879 square miles excluding inland water. In round figures one may say 121,000 square miles or nearly one-eighth of a million. This gives a basis of comparison with other countries —it is equivalent to about one twenty-fifth of continental United States and so on. Out of this total the larger island of Great Britain is roughly 89,000 square miles with 49,000,000 people, the smaller island 32,000 square miles with 4½ million people. The population of the United Kingdom of Great Britain and Northern Ireland with the Isle of Man and the Channel Islands passed the 50,000,000 mark about 1950—on its total area of 94,278 square miles. The census population of the whole United Kingdom in 1951 was 50,423,668. The figures of area given on p. 125 are smaller because inland water is excluded.

REFERENCE

H. J. Mackinder: *Britain and the British Seas*, Oxford: Clarendon Press, 1907.

CHAPTER II

THE PHYSIOGRAPHIC EVOLUTION OF THE BRITISH ISLES

THE present surface features of the British Isles, as well as their relationship to the features of the neighbouring parts of the Continent of Europe, are the reflection of the long and complicated geological history of the area. Geology has been described as geographical evolution, but, conversely, the existing physical geography of a country is the result of its geological evolution from the dawn of geological time to the present day.

The geologist has divided geological time into at least five great eras and each of those eras into a number of periods. On broad lines the rocks which were laid down in each of those periods can be made to tell the story of the earth's history. Each period was characterised by its own sets of animals and plants, the remains of which have been entombed in the rocks and can be found to-day as fossils. Nor are these episodes in the past history of the earth merely of academic interest. Whether it be in the search for minerals of economic importance or the study of the disposition of those deposits when found in its relation to economic costs of mining; whether it be the study of the rocks of the earth's crust in relationship to the soils which they afford or in relationship to construction on the earth's surface, the studies of the geologist are of fundamental importance. No excuse, therefore, need be made for considering in this chapter the physiographic evolution of the British Isles, by attempting to trace the history of these islands from the earliest times to the present.

The five eras—the Pre-Cambrian (in the rocks of which earliest era no remains of life are commonly found), Primary or Palæozoic, Secondary or Mesozoic, Tertiary or Kainozoic (Cenozoic), and, finally, the Quaternary or Modern Period—are the great divisions which the geologist has made in the geological time scale. Subdivisions of these are shown in the diagram, Fig. 4. Further subdivisions are of course made, but those listed are of fundamental importance in that they are in common use for numerous purposes.

Little is known of the geography of Pre-Cambrian times. The rocks of this great era found in the British Isles fall into three main groups:

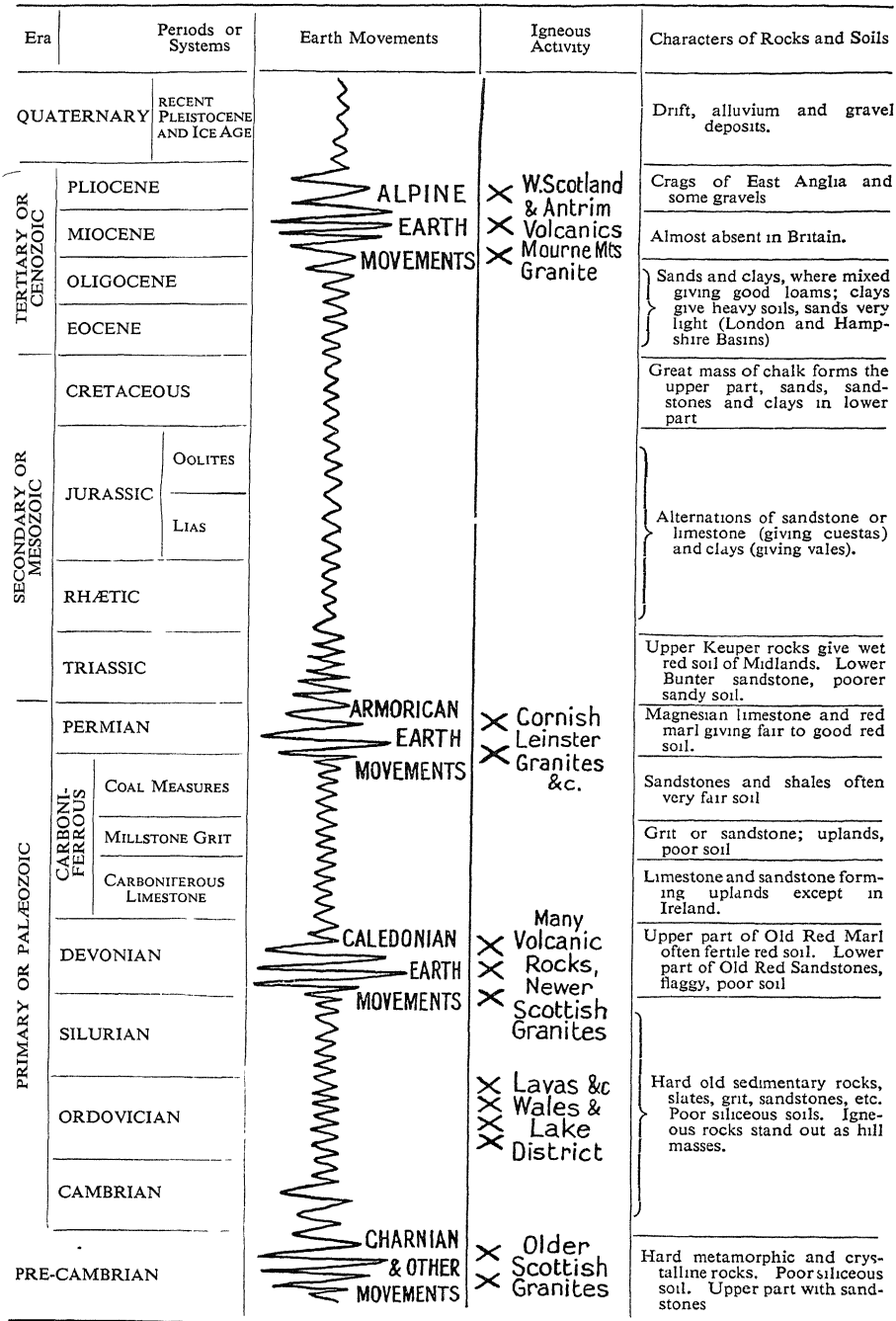


FIG. 4.—Table of geological time periods

(*a*) Crystalline or metamorphic rocks, the descriptive name "metamorphic" indicating that they have changed their form: as the result of heat and pressure they have become recrystallised. They are hard, resistant to weathering, and, except where the continuous action of the agents of denudation through untold ages has slowly but surely worn them down almost to sea-level, they tend to form hill masses. It used to be thought that these hard crystalline rocks represented the original crust of the earth. But in one area after another the Pre-Cambrian crystalline rocks have been shown to represent sediments deposited on a solid crust of an already existing world and which were later much altered.

(*b*) Ancient volcanic, and other igneous, rocks of the same period.

(*c*) Sedimentary rocks, such as sandstones and shales, which have suffered less alteration but which are nevertheless older than the most ancient of the rocks which have yielded fossils.

It seems clear that in Pre-Cambrian times there were at least several great periods of folding or earth movement and volcanic activity, and that the earliest rocks were highly folded and ridged up into great mountain chains, before the deposition of those sandstones and other sediments mentioned under (*c*). Thus it is possible, for example in the north-west Highlands of Scotland, to see the way in which the coarse red sandstones known as the Torridonian and which are themselves Pre-Cambrian, rest in hollows amongst the still older mountains of Pre-Cambrian times. One system of folding developed in some of the small ancient blocks of the Midlands of England, notably in Charnwood Forest, has produced north-west to south-east or "Charnian" folds.

During the first three periods of the Palæozoic era, that is during the Cambrian, the Ordovician, and the Silurian, the earth was inhabited almost exclusively by lowly creatures which had not yet attained the dignity of possessing a backbone. It is possible that during most of these periods a great land mass lay to the north-west of Scotland, and that a broad sea-trough ran across the British Isles. At certain times islands occupied part of Britain and, particularly during the Ordovician, volcanic activity was rife. Some of the volcanoes were submarine and poured out their lavas on the sea floor; others were volcanoes of an explosive type which threw out huge quantities of ashes. Thus we find that the deposits of the Cambrian, the Ordovician, and the Silurian periods are, for the most part, marine sediments, originally clays, silts, sands, and coarser deposits, but inter-bedded with which are found the lavas of contemporary volcanoes and beds of ashes, whilst intruded amongst the sediments are other masses which came up in a molten

condition from the lower layers of the earth's crust and which solidified before reaching the surface. Most of the old sediments have become hardened. The clays have become hard shales and slates, the silts and sands have become sandstones, quartzites, and other hard rocks, so that again the sediments of these three periods tend to form hill and mountain masses and to occur in what will later be described as the Highland Zone of the British Isles. The various igneous rocks are even more resistant to the agents of weathering than are the sediments, and many of the highest mountains of the British Isles are formed of the ancient lavas which were extruded at this time, familiar examples being Snowdon and Cader Idris in North Wales.

Towards the close of Silurian times occurred one of the great periods of mountain building which from time to time have played an enormous part in the determination of the present surface features of the earth. It was during this great period of earth movements that the Highlands of Scotland and the Southern Uplands were formed, and because of its great importance in Scotland the period of folding and the folds produced are known as Caledonian. The Caledonian system of earth movements in these islands resulted, for the most part, in the formation of a series of mountain chains which ran from south-west to north-east. So characteristic is this direction for the mountains that it is known commonly as the Caledonian trend. This dominant trend is very clear in the mountains of the Highlands of Scotland, in the Southern Uplands and their continuation into Ireland, in the mountains of North Wales, and to a less extent is apparent, but nevertheless important, in the Lake District. The Caledonian earth movements commenced towards the end of the Silurian and they were prolonged into the succeeding Devonian period, and the sea-trough of Silurian times disappeared. Most of the British Isles became a land mass, but between the great ridges of mountains were deep mountain-girt valleys or basins. In these torrential streams from the recently formed mountains deposited great thicknesses of coarse conglomerates and sandstones. These are the deposits which we know under the famous name of Old Red Sandstone, and it is remarkable that the Old Red Sandstone deposits often occupy hollows even at the present day, particularly in Scotland. It was only over the south of England that there existed contemporaneously a sea, and in this sea were deposited the Devonian rocks—muds, sands, and silts with local limestones—which form the Devonian Series in Devon, Cornwall, and the adjoining parts of Somerset and are found also over areas in South Wales. In South Wales and the Welsh border they mingle with deposits of Old Red Sandstone type. It may be that the characteristically red colour of the Old Red Sandstone reflects desert conditions in the neighbouring

mountains. Not unnaturally the few fossils which are found in the Old Red Sandstone are of fish, the first back-boned creatures (which lived in the transient lakes of the great mountain valleys) and primitive land plants. The enormous thickness of many of the Old Red Sandstone deposits testifies to the rapidity with which the Caledonian mountains were worn down by the agents of atmospheric weathering. Towards the close of the Devonian period the mountains were already but mere remnants of their former selves and they yielded only fine sand and red mud or marl. The beginning of the succeeding period—the Carboniferous—was marked by a great invasion by the sea of practically the whole area. The sea flowed

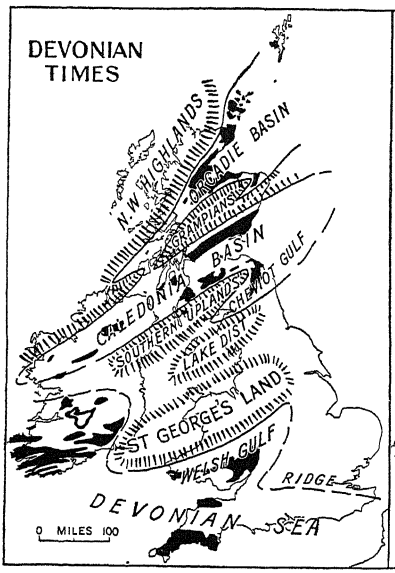


FIG. 5.—The geography of the British Isles in Devonian times

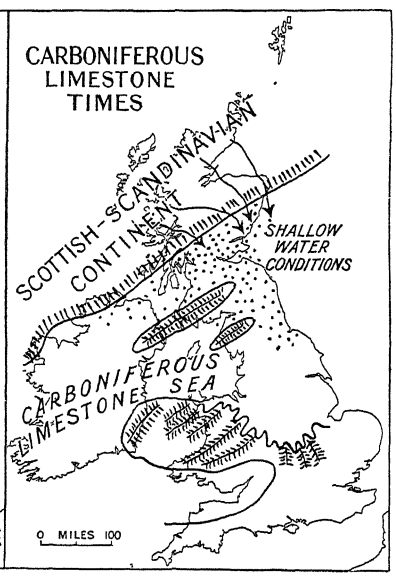


FIG. 6.—The geography of Carboniferous Limestone times

into the pre-existing mountain basins, except in the north where there still existed the great continental mass, whose remnants now form the Highlands of Scotland. Over England and Wales and much of Ireland the mountains had been worn down to such an extent that they yielded but little sediment. In the waters of the Carboniferous sea there flourished a wealth of corals and other organisms which are favoured by clear water; and so the deposits laid down were limestones (Carboniferous Limestone). The name once used for Carboniferous Limestone was the Mountain Limestone indicating the association of this limestone with mountain or upland areas, particularly of the Pennines. But the great continent which extended from Scotland to Scandinavia yielded sediments which

prevented the extensive growth of clear-water organisms in what is now the north of England and the Midland Valley of Scotland. So here one does not see the great thicknesses of Carboniferous Limestone found farther south; instead there are thin beds of limestone in a mass of sandstones and shales. These sandstones and shales represent material brought down by rivers draining from the northern continent. In the middle of the Carboniferous period a huge river gradually began to overwhelm the British area and to spread its great deposits of sand on top of the limestone which had been just formed. We have really in Britain the formation of an enormous delta, and because of the former use of the sandstone of these deltaic

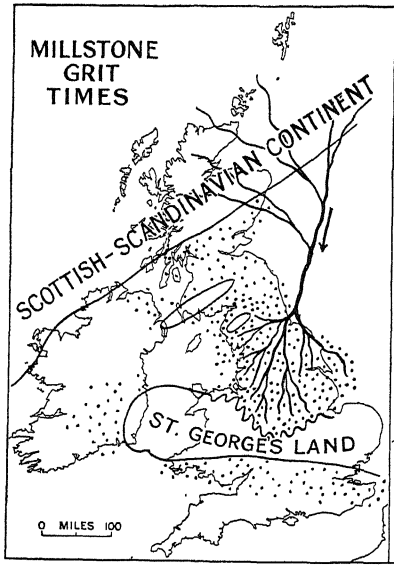


FIG. 7.—The great river delta of Millstone Grit times

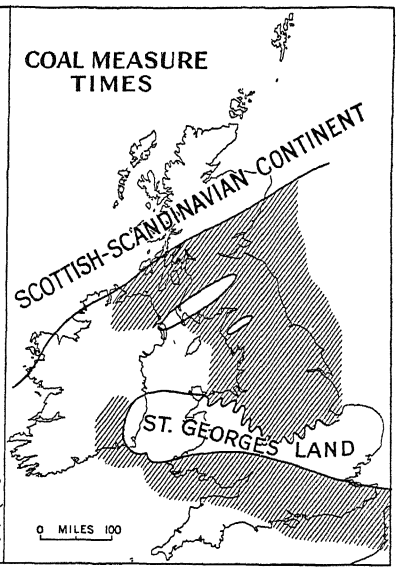


FIG. 8.—The geography of Coal Measure times. The shaded portion shows the area where the coal forests flourished

deposits as millstones the deposits are known as the Millstone Grit. The Millstone Grit delta extended from Scotland right across the Midlands of England as far as an island, or perhaps a peninsula from a European mass, known as St. George's Land, which extended from Central Wales through the heart of England.

The great delta which was formed during Millstone Grit times prepared the way for the very widespread growth of swamp forests in the succeeding period of the Coal Measures. The forests of tree ferns and allied plants, whose remains form the coal seams of the present day, flourished in swampy tracts which have been compared by some to the mangrove swamps of the tropics of to-day,

and by others to fresh-water swamp forests such as the extensive Dismal Swamps of the United States in Virginia. Conditions suitable for the growth of such forests were to be found along the margins of the Scottish land mass as early as Carboniferous Limestone or Millstone Grit times, but it was not until the deposition of the great Millstone Grit delta that conditions became suitable over the huge area between the Scottish land mass, where now one finds the Scottish Highlands, and that land that existed across the middle of Britain and to which the name of St. George's Land has been given. There is little doubt that the Coal Measure forests grew over continuous areas from what is now the Scottish border to the Midlands of England, and right across the area where now the Pennine Upland is found. To the south of St. George's Land, in what is now South Wales, the Forest of Dean, the Bristol area, and right across southern England through east Kent into northern France and Belgium there were similar conditions equally suitable for the growth of forests. It is clear that at intervals the forests were overwhelmed, and indeed entombed, by masses of sand and mud which were brought down by rivers similar in character to those which deposited the Millstone Grit. At other times the slight changes in surface level caused an inrush of the sea, and so in parts of the British Coal Measures there are found thin marine bands. Under most of the British coal seams there are found beds of clay, often with traces of roots, and it would seem that these Coal Measure swamp forests grew in a dark muddy slime, not very different from that in which mangrove swamps grow at the present day. Sometimes this layer of clay underneath the coal seams is of value in that it furnishes fireclay. Occasionally it has become silicified and is important as "ganister." There is little doubt that the land masses of Coal Measure times had been worn down greatly, in fact almost to sea-level, and towards the close of the period there is evidence that desert conditions prevailed on the neighbouring land masses.

The close of Coal Measure times is marked in many parts of the world by a great series of mountain-building movements, frequently known as the Carbo-Permian earth movements, since the succeeding period is that of the Permian. In the British Isles these movements resulted in four sets of folds:

(1) In the north and north-west of the islands the Carbo-Permian movements resulted in the accentuation of pre-existing folds which had been formed by the Caledonian earth movements.

(2) In such areas as central Wales new folds were formed, broadly speaking parallel to the pre-existing Caledonian folds, that is with a trend from south-west to north-east. The great anticline of the Vale of Towy in Central Wales is a good example.

(3) The most characteristic folds, however, of the Carbo-Permian earth movements are those which have an east and west trend and which are best exemplified in the folding of South Wales and the formation of the South Wales coal basin. The highly complex folds with their axes roughly from east to west which are found in Devon and Cornwall are also of this period, and there they were accompanied by the intrusion of vast masses of granite. On the other side of the Channel the east-west folds of Brittany are of the same age. Brittany, or "Armorica," shows the folds of the Carbo-Permian earth movements so well that they are known as the Armorican earth movements or, alternately, as the Hercynian, from the Harz mountains of Germany.

(4) In other parts of England north-south folds characterise this period and there is little doubt that the general uplift of the Pennines which resulted in the separation of the Coal Measures into an eastern and a western series of basins originated at this time. Another north-south fold typically Carbo-Permian is the line of the Malvern Hills, which now forms the eastern limit of the massif of ancient rocks making up Wales.

As a result of these great Armorican earth movements, at the beginning of Permian times Britain was occupied by an important series of mountains, between which there were deep mountain-girt desert basins—and naturally the earliest Permian deposits are usually coarse breccias which are of the nature of screes from the newly formed mountains. Beds of coarse conglomerate and boulders, laid down by torrential streams, are also found. There is one very well-known Permian basin containing rocks of this character, and that is the one which occurs in the south-west, over the eastern parts of what is now the county of Devon and the neighbouring parts of Somerset. A great sea, or possibly salt-water lake, comparable to the Caspian at the present day, covered much of Germany. It may, or may not, have been continuous with the main ocean which lay to the south of Europe. This German sea stretched across the North Sea and its western shores were to be found in northern England. After the early sandy deposits the well-known Magnesian Limestone was laid down in the north of England and is found in its best development in Durham and Yorkshire. The waters of the Magnesian Sea seem to have found their way round the southern edge and perhaps across the north of the newly formed Pennines, and attenuated remnants of the Magnesian Limestone are therefore found on the western side of the Pennines. There is little doubt that the land surrounding these areas was under desert-like conditions; most of the sandstones and marls of Permian age are red; many of them contain grains of sand worn smooth by

wind action. The Permian deposits thus form the lower part of what the older geologists described as the New Red Sandstone. This name was not ill-chosen, since the conditions of deposition of the beds must have closely resembled those of the Old Red Sandstone.

Although the Permian is the youngest of the Primary or Palæozoic systems, there is little break in England between the Permian deposits and those of the succeeding Trias, the oldest of the Secondary or Mesozoic. The Trias takes its name from the three-fold division which is possible in the rocks of this series in most parts of northern Europe into Bunter, Muschelkalk, and Keuper. The coarse red sandstones and pebble beds of the Bunter period were laid down in

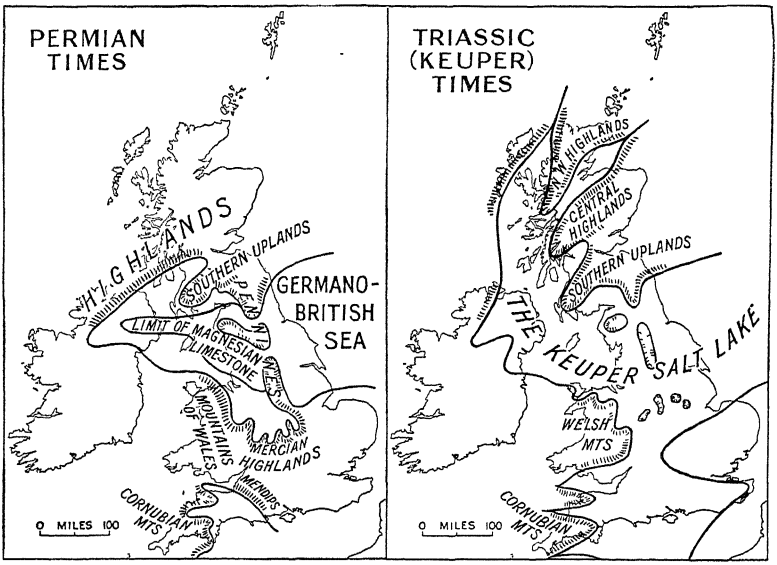


FIG. 9.—The seas and salt lakes of Permian times after the Carbo-Permian earth-building movements

FIG 10.—The geography of Keuper times

roughly the same areas as the Permian deposits. Like the Magnesian Limestone, the Muschelkalk of Germany and much of Europe was laid down in an inland sea, doubtless a salt-water sea, which, like the Magnesian Limestone sea, stretched from Germany across towards England. The Muschelkalk itself as a limestone is, however, absent from England. Here the Bunter Sandstones are succeeded by a considerable thickness of red sandstones and marls (Keuper) which were clearly laid down in a shallow basin surrounded by desert country. At intervals this basin was dry, for one finds deposits of salt (of considerable economic importance) and gypsum representing salts that were deposited when the shallow

basins dried up. Many of the deposits are ripple-marked; others show "pittings" due to rain storms on the scarcely dry mud. This was an age when giant reptiles first began to be important and the remains of some of them are entombed in the Triassic deposits. Some of the masses of older rocks—the remnants of the Carbo-Permian Mountains—stood up as islands in the Triassic salt lake or sea of the Midlands of England. Examples are preserved to us to-day in the Wrekin, the Lickey Hills, and the hills of Charnwood Forest, so that one finds the red Keuper deposits wrapping round the margins of the ancient rocks. It is the red Keuper Sandstones and Marls together with glacial drifts largely derived therefrom which are in the main responsible for the red soils so common in the Midlands of England. The Marls give rise to a soil which is rich, though tending to be waterlogged, but fertile for agricultural purposes if well drained.

The next phase in the physiographic evolution of the British Isles began with the irruption of a sea into the old Triassic basins. Many of the creatures living in the Triassic Sea, such as fishes, were killed off by this sudden incursion of marine waters, whilst organisms which were brought in by the marine waters found themselves unable to survive under the new conditions. Hence it is not surprising to find the earliest deposits of the Rhætic, as the succeeding period is called, consist frequently of "bone beds," built up entirely of the remains of fishes and of reptiles. But in time the sea covered the whole area of the Triassic basins and even overstepped them on to the neighbouring land masses. By this time the land masses were worn down so that the material they yielded was more often of the nature of fine sands and muds, rather than coarse deposits. Conditions favoured the development of certain types of limestone. Deposits attributed to the Rhætic on the Continent of Europe often attain a great thickness but in Britain the whole period is represented by only a thin series of deposits. The important Jurassic period which succeeds it is represented by a great series of beds which can be divided into three great groups. The Lower Jurassic deposits were the Liassic deposits and are mainly of clay or mud, argillaceous limestones, and occasional sands. In the water of the Jurassic seas enormous numbers of the well-known ammonites flourished, and these are really the dominant fossils of the period. Although there were no great earth-building movements during the Jurassic period, there were doubtless small folding movements; and the deposits of the Middle Jurassic comprise limestones, sandstones, and clays laid down in the tranquil waters of basins more or less cut off from one another.[1] Where the waters were clear and free from sediment the conditions were particularly

[1] This accounts for the discontinuous character of the scarps formed by the harder beds (see p. 48).

suitable for the accumulation of the well-known Oolitic Limestones, and the famous freestones of Bath belong to this period. In the Upper Jurassic, on the other hand, clays and sands again predominate over the calcareous deposits though the famous Portland stone is of this age. The difference between the soft and easily eroded clays and the harder beds by which they are separated has been a factor of the utmost importance in determining the relief of the present day south-east of England. Towards the close of the Jurassic period the sea retreated to the north-east, whilst the extreme south-east of England was covered by a great lake, the Wealden Lake, which stretched across what is now the English Channel into France. In this Wealden Lake were laid down deposits of sand and clay, such as the Hastings Sand and the succeeding Weald Clay found at the present day in the heart of the Weald of Kent, Surrey, and Sussex. Around this Wealden Lake lived enormous numbers of giant reptiles such as Iguanodons, whose remains are found in the lake deposits. In the seas which still covered the north-east of England were deposited various beds, including the Speeton Clay of Yorkshire.

Just as the Triassic Lake basins were later invaded by Rhætic seas, so the Wealden Lake basin and the northern marine area were afterwards invaded by the sea of the earlier Cretaceous period. Naturally the earlier deposits were sands and muds, but there had been no extensive earth-building movements affecting Britain since Carbo-Permian times, so that the land surrounding the invading Cretaceous seas were low and yielded but little sediment. There is evidence that on these lands a desert type of climate prevailed. After the formation of the Greensand and Gault Clay deposits the waters of the Cretaceous seas became deeper and were extremely clear. The conditions thus favoured the deposition of one of the most famous of all the deposits found in the British Isles, that remarkably pure white limestone which we know as Chalk. It used to be thought that the Chalk was laid down in deep water under conditions comparable to those prevailing in the open Atlantic Ocean where white "oozes" are being formed at the present day, but it is now believed that the Chalk sea was not necessarily a deep sea, but merely one in which the water was clear owing to the absence of sediment brought from the land. The Chalk itself consists partly of the remains of multitudes of tiny organisms, particularly of foraminifera. The exact limits of the Chalk sea in Britain are not easy to determine. It is believed by many that the peneplanation or the smoothing of the mountains of Wales, and possibly even of parts of the Highlands of Scotland, is due to the action of the waves of the Chalk sea.

The Cretaceous is the youngest of the periods of the great Mesozoic or Secondary era. Although in Britain there is comparatively little discordance between the bedding-planes of the Chalk and of

the succeeding deposits there is a great change of character between the two. There was actually a considerable lapse of geological time between the deposition from highest Chalk and the succeeding beds. The earliest of the Tertiary deposits in Britain are the Eocene, and with this period Britain began to assume some of the relief features which are so familiar at the present day. Most of Britain seems to have risen so as to form a great land mass and only the south-east of the country was covered by a sea. Into this sea there emptied one or more great rivers coming from the west from a continental mass which is now beneath the waves of the Atlantic

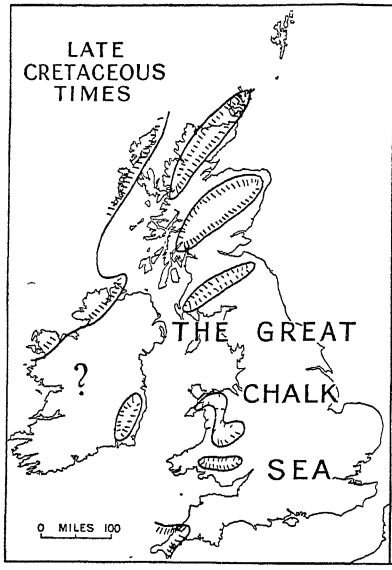


FIG. 11.—Map showing the area *probably* covered by the Chalk Sea

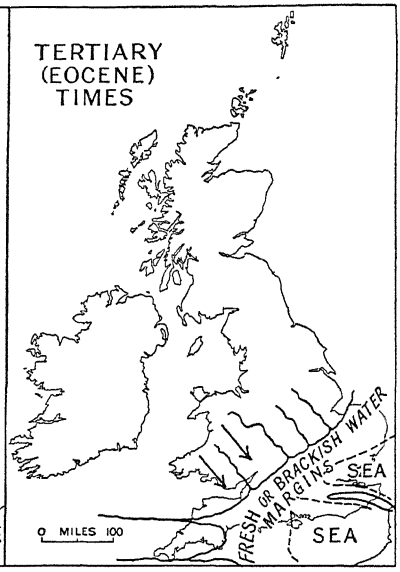


FIG. 12.—The geography of Eocene times

Ocean. The rivers laid down sands and other deposits of predominantly continental origin in the western parts of what we call the Hampshire and London Basins, whilst towards the east of these same basins there were being deposited clays or muds containing marine fossils. There is on the whole an alternating succession of deposits of marine and continental origin which marks the various backward and forward movements of the marine waters of the Eocene sea.[1] The same sea covered the well-known Paris Basin in the northern part of France as well as considerable tracts in Belgium and Holland. It was during the Eocene period that there occurred some

[1] Economically this is of the utmost importance because of the variety of soils and consequent land utilisation which result.

of the earlier earth tremors which were gradually to increase in strength and to culminate in those earth-building movements which were the most important of all in determining the present physiography of Europe—the Alpine earth movements. It seems likely that the Wealden dome in south-eastern England began to rise during the Eocene period.

The Oligocene period, which succeeds the Eocene, has left but little trace in Britain. If there were Oligocene deposits laid down in the London Basin they have been removed by denudation and Oligocene deposits are almost restricted in this country to the Hampshire

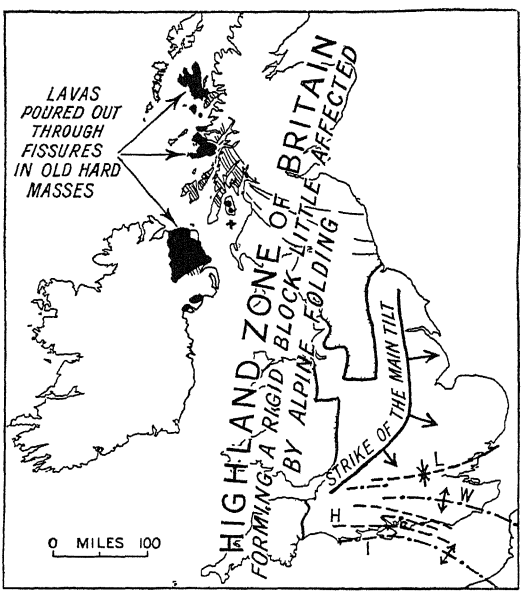


FIG. 13.—Map of the British Isles showing the effects of the Alpine earth movements. The arrows show the dips of the rocks. The fine black lines in the north of England and in Scotland are dykes of igneous rock of the same age filling cracks.

Basin. Towards the close of the Oligocene and during the succeeding Miocene period the great Alpine storm broke. This great period of earth-building movements formed the Alps, the Carpathians, and many of the other great mountain chains of the world. The British Isles were comparatively little affected, since earlier folding movements had exerted their full influence in the north and the north-west of the country and resulted in the formation there of great stable blocks too rigid to be further folded by the earth-building movements so paramount in central Europe, and were at the same time too distant from the main seat of the Alpine

storms. It is to be expected that the southern parts of England would be the areas most affected by the Alpine movements; that is actually the case. The folds, for example, which run across the Isle of Purbeck and the Isle of Wight are of this age. The main folding of the Weald is also of the same date. Whilst the ancient rocks of the north of the British Isles were not folded they were

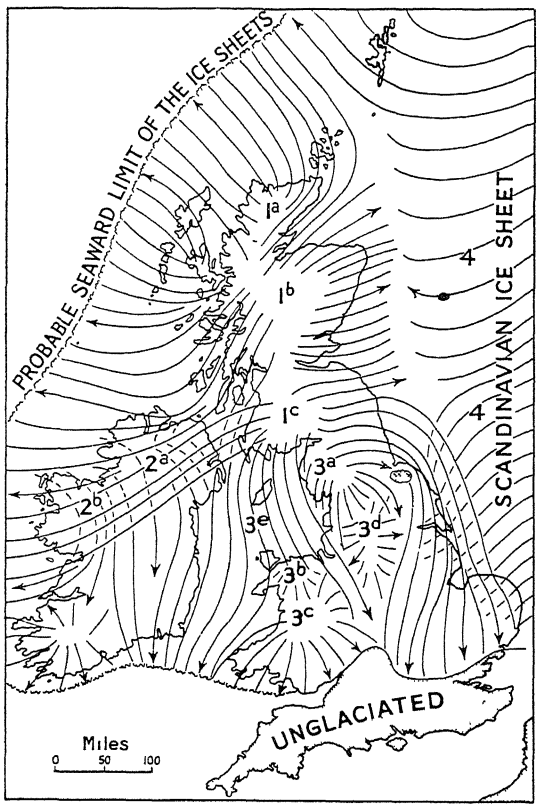


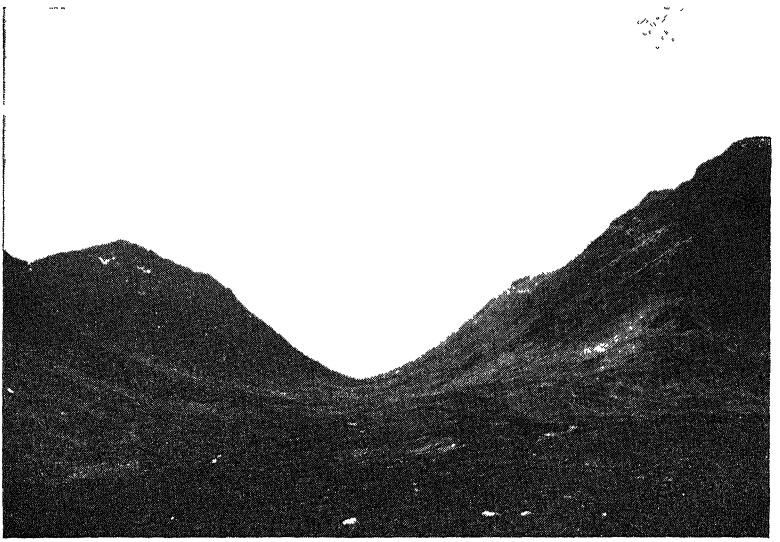
FIG. 14.—The great Ice Age in Britain

The arrows show the direction of movement of the ice sheets. The local ice caps are: 1*a*, North West Highlands; 1*b*, Grampians; 1*c*, Southern Uplands, 2*a* and 2*b*, Northern Ireland, 3*a*, Lake District; 3*b*, North Wales; 3*c*, Central Wales; 3*d*, Southern Pennines, 3*e*, Irish Sea.

rent and torn, and through some of the fractures burst enormous flows of molten rock giving rise to the lava plateaus of Antrim in Northern Ireland and of many parts of western Scotland, whilst some of the great granitic intrusions, such as the granite mass of the Mourne Mountains in Ireland and some in Scotland, belong to the same period. The succeeding Pliocene period saw Britain taking on very much the form that it has at the present day. The Pliocene

sea lingered in what is now the London Basin and later retreated farther north and occupied the position of what is now the North Sea, so that Pliocene deposits in this country are restricted, broadly speaking, to the London Basin and to East Anglia. More important than the deposits left behind was the work of Pliocene seas, in cutting those flattened surfaces, bevelling many of our hills especially in southern England. It is only in recent years that the geological history of the times has been worked out from this fragmentary evidence.

There was still to come, however, an episode in the geological history of these islands which has left its mark in nearly all places:



[Photo: L. D. Stamp

FIG. 15.—Glen Etive, Western Scotland—a typical U-shaped glaciated valley in the Highlands, showing a complete absence of spurs

and that was the great Ice Age. At the height of the Glacial Period the greater part of the British Isles was covered with ice sheets. Some of these were of local origin and had their centres in such upland areas as the Highlands of Scotland, the Southern Uplands or the mountains of Ireland, whilst other parts of the British Isles, particularly the east, were affected by the enormous ice sheet which crossed the North Sea from the main centre of the Scandinavian mountains. The southern limit of the ice sheets in Britain ran roughly along the present day line of the Thames, so that Britain south of the Thames and of the Bristol Channel was not actually covered by the ice sheet. The Ice Age is of enormous importance because of the way in which the ice-sheets and glaciers

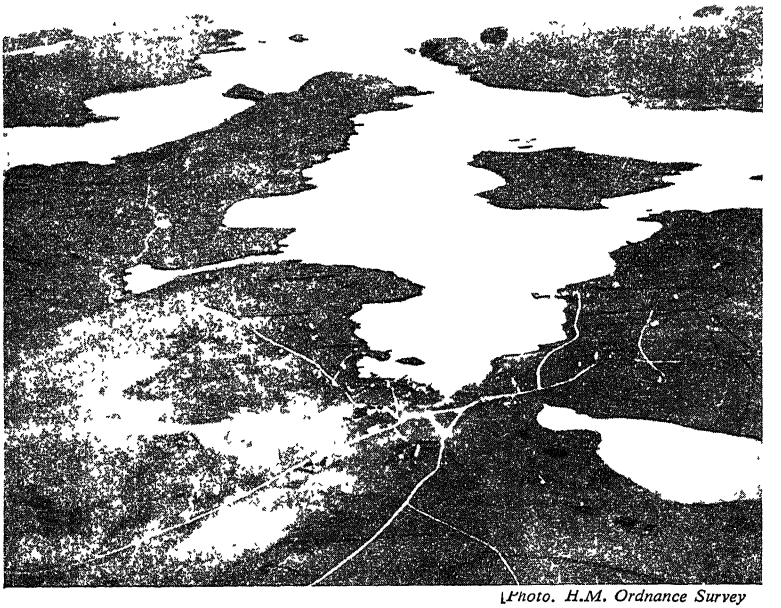
moulded the surface of the country and left behind them various superficial deposits which are frequently of much greater importance in determining the character of surface utilisation than are the underlying solid deposits to which the geologist pays greatest attention. Thus the ordinary geological map of the British Isles is really of comparatively little use to the geographer in his attempt to interpret the effect of soil on human activities and as a factor in the human environment. It is of utmost importance that he should consider what the geologist calls the "drift" map, the map which shows not only the solid rocks underneath but the superficial deposits, many of which are directly or indirectly connected with the great Ice Age. In general it may be said that the great Ice Age had at least the following effects:

(1) The ice removed much of the soil which must previously have been formed in the mountainous areas and has rendered huge tracts of the Highlands of Scotland, for example, almost devoid of soil and therefore comparatively useless for agricultural purposes. The older rocks are exposed at the surface and have been smoothed by ice action, and one sees in the rounded outlines of the relief of the Highlands some of the results of the work of ice. Tongues of ice scooped out pre-existing valleys and smoothed the sides and gave the characteristic U-shaped valleys, with sides almost devoid of soils, which one finds throughout the Highlands and, indeed, in many parts of northern England and Wales and of Ireland.

(2) Over the low-lying areas glacial deposits were laid down. Some of these consist of coarse sands and even of boulders of morainic character. Elsewhere there are boulder clays—stiff clays full of boulders of various rocks. Or again, there are outwash fans of gravel and sand which were laid down by torrential waters caused by the melting of the glaciers. In the fourth place, some of the finer glacial deposits were redistributed by wind, and whilst the climate of England seems to have been too humid for the formation of vast quantities of loess, which are found in regions where conditions south of the ice masses were drier, the brick-earth of England has many of the characters of loess, and is really loess deposited under more humid conditions or under water. These brick-earths are essentially characteristic of the south of the country.

(3) Then the glaciers profoundly altered the drainage of the British Isles and there are innumerable examples of pre-existing drainage which has been affected by the Ice Age. Many ice-dammed lakes were left during and after the retreat of the ice and to-day the fine sediments deposited in these glacial lakes afford some of our most fertile lands.

Since the retreat of the ice sheets from the British Isles there have been several fluctuations in level. Evidences of these fluctuations in level are found in the raised beaches which occur in many places along the coasts, whilst movements of the opposite character are evidenced by submerged forests. Then, again, one must always remember that there has been a progressive change from the extreme cold of the great Ice Age to the climatic conditions



[*Photo. H.M. Ordnance Survey*

FIG. 16.—Aerial view of part of the Shetland Islands, showing a glaciated land surface drowned by the sea

which are found at the present day, though the change may have been interrupted by cyclic fluctuations. The spread of the present vegetation into these islands must have been governed by the changing climatic conditions; doubtless, very considerable portions of the pre-glacial flora managed to persist in the south of the country and formed the nucleus for the reclothing of the British Isles.

The evolution of the rivers and drainage system of Britain will be separately considered; but it should be borne in mind here that there was a drainage system in existence prior to the formation of the ice sheets of the great Ice Age, and that this earlier drainage system was profoundly affected by ice action, and that the present river system of these islands reflects in most cases the result of glacial interference.

References.—The reader will find the evolution of the present geography of the British Isles treated along these lines in L. D. Stamp's *Introduction to Stratigraphy* (Thomas Murby & Co., London, Third Edition, 1950) and in L. D. Stamp's *Britain's Structure and Scenery* (Collins, London, 1947). The same subject is elaborated in greater detail in L. J. Wills' *Physiographic Evolution of Britain* (Edward Arnold, 1929). In these works full references will be found. In addition Professor Wills has prepared a *Palæogeographical Atlas* (Blackie, London, 1951).

CHAPTER III

THE PHYSIOGRAPHY OF THE BRITISH ISLES

IN the last chapter, by considering the changes in the distribution of land and water over successive geological periods, we have traced in bare outline the evolution of the physiography of these islands. In the present chapter we must analyse the physiography as it is at the present day. Leaving on one side for the moment the island of Ireland, the island of Britain is broadly divisible into two parts: a Highland Zone on the north and west, a Lowland Zone on the south and east. It is possible to suggest more than one line which may be used to separate these two divisions, but the most satisfactory seems to be that used in Fig. 17 and elsewhere in this book (see Chapter XXIV) and which cuts across the country, following a somewhat irregular course, from the mouth of the River Exe in the south-west to near the mouth of the River Tees in the north-east. It is roughly the line separating the outcrop of the old Palæozoic rocks on the one hand and the younger Mesozoic and Tertiary rocks on the other. To the north and west of the line lie the remnants of the great mountain chains which were built up by successive earthbuilding movements of Pre-Cambrian, Siluro-Devonian, and Carbo-Permian times. The mountains are but remnants of their former mighty selves, but they still comprise the major mountain and hill masses of Britain. Generally the most ancient masses are those which occur, as in the case of the Highlands of Scotland, farthest to the north-west. Naturally the margins of the ancient rocks are not infrequently covered by strata of later ages.

FIG. 17.—The Highland and Lowland Zones of Britain

To the south and east of the line one finds first the broad plains or low-lying plateaus, built up mainly of Triassic rocks, which constitute the Midlands of England. Not infrequently small remnants of the ancient mountains stand up as islands in the midst of these plains of younger rocks. Farther southwards and eastwards the Midland plains give place to what may be called, in the broadest

possible sense, the scarplands of England. Indeed, it is possible to draw another line across England, again somewhat irregularly, from the Dorset coast to the north Yorkshire coast. To the south and east of this line lie low ridges, separated by shallow valleys, which mark respectively the outcrop of the harder or more resistant and softer or less resistant beds respectively of the geological sequence from the early Jurassic onwards. Like the Triassic rocks of the Midlands, these rocks rest upon an ancient platform which lies buried beneath them at a greater or less depth.

Sometimes, as for example under London, the ancient platform is within a thousand feet of the surface. At other times the Palæozoic platform lies at such a depth that the full thickness of the overlying beds has never been penetrated by the boring tools of the well-engineer. The Jurassic and later rocks have themselves been gently tilted, usually towards the south-east, by the Alpine system of earth movements; but it is only in the extreme south that there are signs of what might be called severe folding.

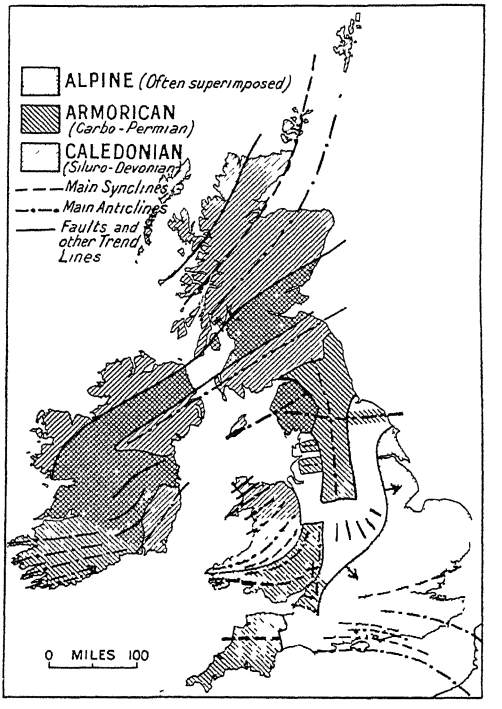


FIG. 18.—Morphological map of the British Isles, showing the spheres of influence of the main folding movements

For the purposes of a preliminary account we may distinguish in Britain the broad physiographic and structural units described in the following pages.

A. THE HIGHLAND ZONE

(1) **The Highlands of Scotland.**—The Highlands of Scotland are built up for the most part of great masses of ancient metamorphic or crystalline rocks—gneiss, schists, slates, and quartzites. Some of the folding doubtless took place in Pre-Cambrian times, and it would seem that some of the great intrusions of granite and of

other rocks are of the same date. The great period of earth movements which determined the major structures of the Scottish Highlands was, however, the Caledonian, or Siluro-Devonian. These movements gave rise to great mountain chains with a general trend from south-west to north-east, and this is still the dominant "grain" of the country. Between the great mountain chains were the deep basins in which the deposits of the Old Red Sandstone

FIG. 19.—Physical Regions of the British Isles

were laid down. Much of the Highlands of Scotland has probably remained land from those very remote ages to the present day, and consequently sub-aerial denudation has gone on almost continuously, culminating with the work of the great ice caps which covered Scotland during the last glacial epoch. As a result, the Highlands of Scotland of to-day no longer present the highly accidented scenery of the younger mountain belts of the world, but rather the rounded outlines which betoken the results of æons of sub-aerial denudation and the work of ice. On the whole, then, the Highlands form an

irregularly surfaced plateau with its greatest elevation along the western margin, sloping on the whole towards the east. The plateau surface has in general an average elevation of between 2,000 and 3,000 feet; some of the higher points often marking the outcrops of granite, of both Pre-Cambrian and Siluro-Devonian ages. The highest points may reach over 4,000 feet, and included amongst them is Ben Nevis, the highest mountain in the British Isles, of 4,400 feet. The Scottish Highlands are divided into the North-West Highlands and the Central Highlands or Grampians by the great cleft of Glen More. The North-West Highlands are by far the more rugged and the grander, and meet the Atlantic Ocean in the intricate fiorded and island-bounded coast of western Scotland. It seems possible that the Alpine earth movements,

FIG. 20.—The diagram on the left shows cracks which would be developed in a rigid block by pressure from below at a point near the north-east corner. On the right is shown a part of the fiord coast of Western Scotland—water in black, main valleys dotted

being unable to fold the old stable block, tended to fracture it instead, and the belts of crushed rock which were formed along the fractures have been more easily excavated by rivers and by ice, and by the waves of the ocean, thus giving rise to the fiords with their remarkable rectangular bends.[1] Through some of the major cracks,

[1] The system of major cracks developed along the western coasts of Scotland may be due to pressure exerted from below by masses of molten rock attempting to find an outlet. Just as when one presses with the point of a stick on a sheet of ice covering a pond, or when a stone is thrown through a window, both concentric and radial cracks would be developed, and it would seem that this explains the varied directions followed by the fiords and valleys of the area. See J. W. Gregory, "The Origin and Nature of Fiords"; and J. W. Gregory, "The Scottish Lochs and their Origin," *Proc. R. Phil. Soc. Glasgow*, XLV, 1914, 183–196.

too, igneous rocks of Tertiary age have welled up and give rise to the marked lava plateaus of Skye and some other parts of the western coast of Scotland, comparable in character to those found in Iceland. The Old Red Sandstone, originally deposited in valleys, still tends to occur in valley or lowland situations, but the more resistant rocks of the period may cover considerable stretches, as they do over Caithness.

The ancient rocks of the Highlands on the whole give rise to a poor type of soil, whilst much of the soil which must previously have been formed has been swept away from most of the higher areas by the ice sheets of the glacial epoch. The tracts occurring on the Old Red Sandstone are, on the whole, more fertile. The same is true of the lower eastern margins of the ancient rocks themselves, as for example in the area known as the Buchan Plateau. Geographically, the eastern margins, whether they are on the ancient rocks or on Old Red Sandstone, are somewhat distinct from the main mass of the Highlands and are frequently considered as a separate region under the title of North-Eastern Scotland. It should be noted that the Orkney Islands form a detached portion of this area, whilst the Shetland Islands, farther north, resemble more closely the central part of the Highlands themselves. The southern limit of the Highlands of Scotland is remarkably well defined by the great Highland boundary fault, actually a succession of faults, which runs across the country with a Caledonian trend, from the mouth of the Clyde to the east coast in the neighbourhood of Stonehaven. The faults seem to have been initiated at the same time as the Caledonian earth movements, but intermittent movements along them have undoubtedly occurred from that time until the present.

(2) **The Southern Uplands.**—The Southern Uplands consist of the denuded remains of a great mountain chain of Siluro-Devonian age and which runs across the south of Scotland from the south-west to the north-east, that is with a characteristically Caledonian trend. There is, however, a marked difference between the Southern Uplands and the Highlands, in that the rocks of which the Southern Uplands consist are sediments, mainly of Ordovician and Silurian age, very highly folded. In the south-west, particularly in Galloway, there are large granitic intrusions, but ancient metamorphic rocks, such as those constituting the greater part of the Highlands, are absent. Consequently all the higher parts of the Southern Uplands are formed of moorland country with rounded outlines, passing on lower ground in the east, particularly in the Tweed basin, to quiet rolling pastoral, and often well-wooded country. In the south-west, cutting across the main mass of the Southern Uplands, are the well-known dales. These dales are comparatively straight clefts running from north-north-west to south-south-east and afford

important routeways. Fringing the Southern Uplands, along the shores of the Irish Sea, are stretches of low ground, occupied by smiling, well-watered pasture. The northern limit of the Southern Uplands is formed by a great zone of faulting, comparable in character to the fault-line which bounds the Highlands, though not giving rise to such a marked feature.

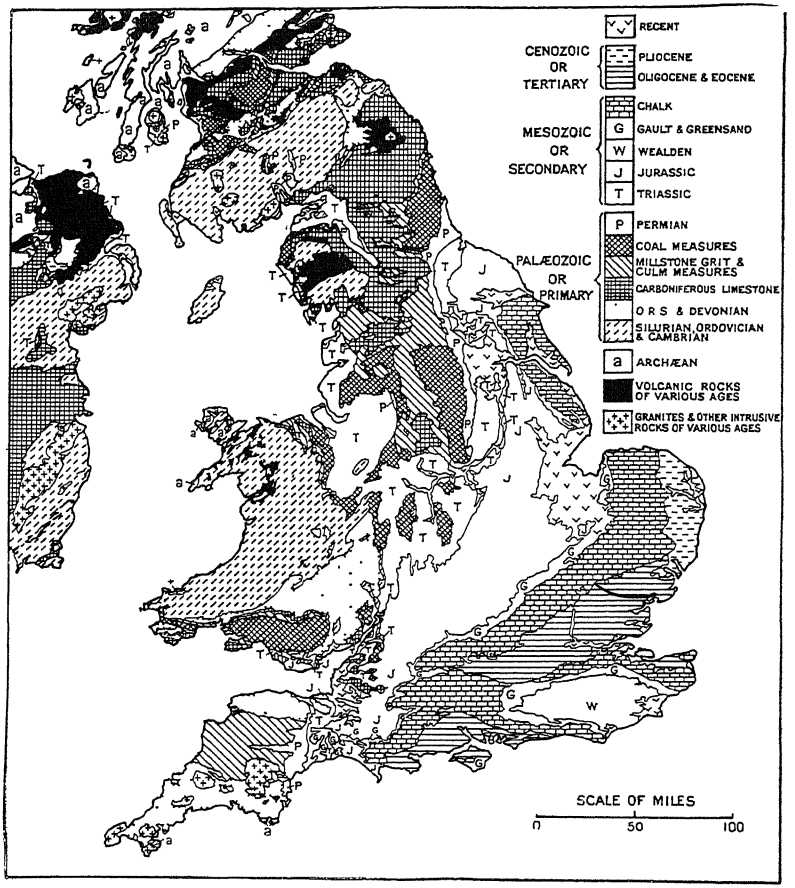


FIG. 21.—A simplified geological map of England and Wales

For reference purposes use should be made of the Geological Map of Great Britain on the scale of 1.625,000 (approximately 10 miles to one inch) published in two sheets by the Geological Survey (H M.S.O)

(3) **The Central Lowlands, or Midland Valley, of Scotland.**—Lying between the Highlands on the north and the Southern Uplands on the south is the great rift valley which forms central Scotland. Initiated by the Caledonian earth movements it was a basin of

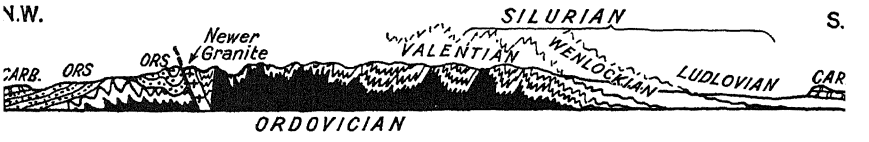


FIG. 22.—Section across the Southern Uplands

O.R.S. = Old Red Sandstone; Carb. = Carboniferous

deposition of the Old Red Sandstone, and was later occupied by a shallow arm of the Carboniferous sea, so shallow that at an early stage it was suitable for the growth of the swamp forests which have left their traces at the present day in seams of coal. At the same period volcanic activity was rife, and as a general result at the present day neither the relief nor the geology of the Midland Valley of Scotland can be described as simple. It is only in the broadest possible sense a valley. It is possible to distinguish a northern fringing corridor or broad valley, then a line of volcanic hills, then the central lowlands wherein lie the great Lanarkshire or Central Coalfields and the Midlothian-Fifeshire Coalfield, then a line of hills along the south and an ill-defined valley separating them in turn from the Southern Uplands. These sub-divisions of the valley and their correlation with the geology may be seen in Figs. 23 and 24.

(4) **The Lake District or Cumbria.**—The folding of the mountains which now make up the Lake District probably commenced even as early as Ordovician times, but the main earth movements responsible for the formation of the group were, like those of the Southern Uplands and of the Highlands, the great Caledonian movements. Consequently the geological structures in the main part of the Lake District have a trend from south-west to north-east and there is no doubt that originally the Isle of Man and the Lake District were joined and formed a single great chain of mountains. But the mountains suffered great denudation, and at a later stage the waters of the Carboniferous sea washed round them and may even have submerged the whole, so that Carboniferous Limestone was deposited on the flanks of the old central core. At a later stage—probably during the Alpine earth movements—a local uplift occurred in the heart of the Lake District. The uplift may have been due to a great mass of molten material in the lower layers of the earth's crust attempting, without success, to force its way to the earth's surface. Whatever its cause, the uplift has undoubtedly resulted in the two great characteristic features of the area of the present day. These two features are the occurrence of the main mass of ancient rocks in the heart of the area, surrounded

by younger rocks which in general dip away from the centre core. In the second place the uplift seems to have been responsible for the initiation of one of the most remarkable examples of radial

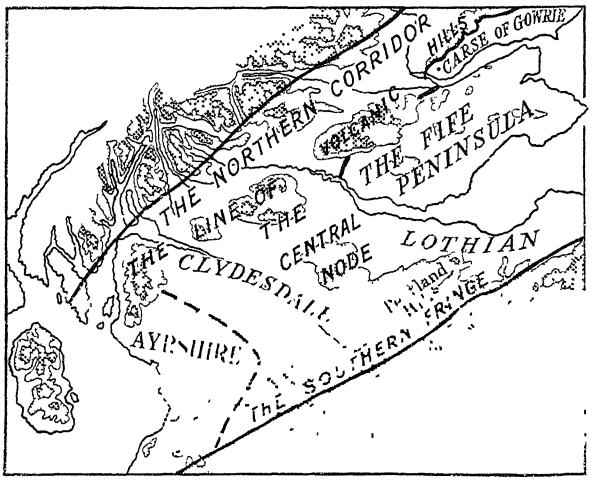


FIG. 23.—Sub-regions of the Midland Valley

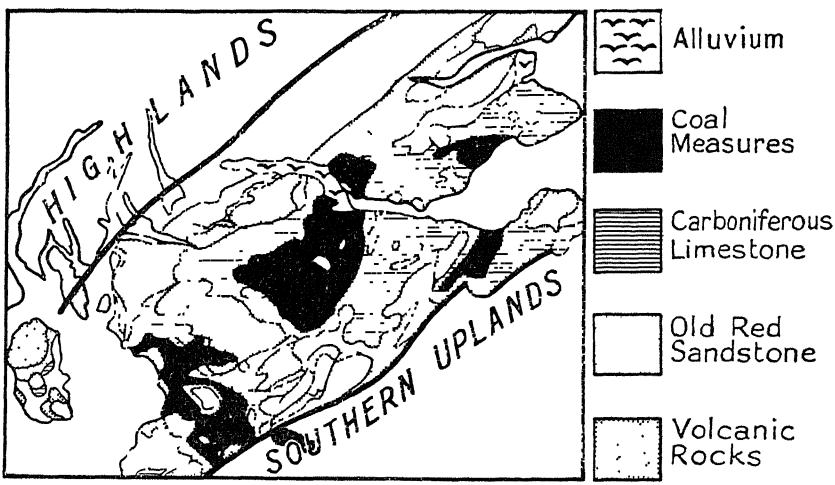


FIG. 24.—The geology of the Midland Valley

Note the separation of the Ayrshire and Central coal basins by the Cunningham axis of uplift (N.W.–S.E.) and the separation of the Central and Midlothian by the Pentland axis (S.W.–N.E.).

drainage which is known. The well-known lakes of the Lake District radiate like the spokes of a wheel from a central hub, and it is because this uplift took place at a comparatively late stage

that the forces of denudation are still active. Thus the Lake District has some of the finest rock scenery and, despite their relatively low altitude, rugged mountains in the British Isles. Geographically there is a remarkable contrast between the area of ancient rocks in the heart of the Lake District and the surrounding ring of younger strata. Only on the south-east do the Shap Fells connect the Lake District proper with the hill masses of the Pennines.

(5) **Wales or the Welsh massif.**—For the purposes of a general account the whole of the Welsh massif may be considered together.

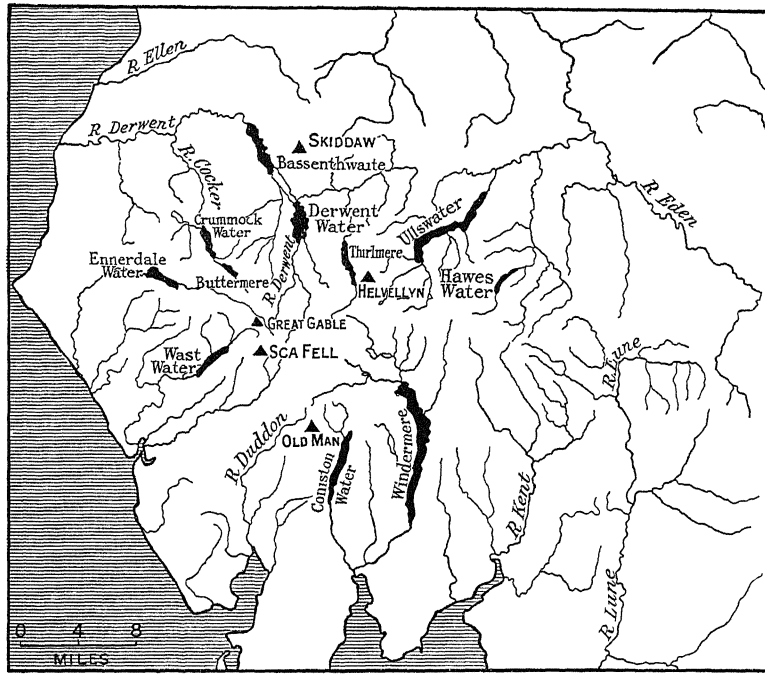


FIG. 25.—The radial drainage of the Lake District

For this purpose the massif may be described as embracing all the hill masses which lie to the west of the English Midlands, excluding only the southern part of the county of Glamorgan, which actually ought to be considered as part of the English plain or scarplands. The eastern margins of the area so defined can be quite clearly traced from any physical map. In the north the Welsh hills abut quite abruptly on the Cheshire and north Shropshire plain; along the margin lies the North Wales Coalfield. The hills of central and southern Shropshire belong structurally to

the Welsh massif, and from central Shropshire southwards to the mouth of the Severn the eastern limit is defined by the line of hills running southwards from the Wrekin in Shropshire to the Abberley Hills and the Malvern Hills. The oldest part of the Welsh massif is in the north-west, where the ancient crystalline rocks of the isle of Anglesey underwent folding in Pre-Cambrian times. The folding was continued during the Caledonian earth movements and post-Carboniferous foldings followed along the same lines, so that one finds narrow bands of Carboniferous Limestone pinched in amongst the ancient rocks. The whole of Anglesey, as the result of later denudation, has been worn down to a low plateau, almost to a sea-level plain, and its complicated geological history is scarcely suggested by the somewhat uninteresting surface features of the island. The mainland of north Wales is still, on the other hand, a land of rugged mountains. On the whole the grain of the country is from south-west to north-east, indicating that the mountains owe their origin in the main to the Caledonian earth movements. The rocks involved in the folding are, for the most part, Cambrian, Ordovician and Silurian, but the mountains owe their rugged character of to-day to the large masses of contemporaneous lava which were extruded as well as to other igneous masses which were intruded into the rocks before and during the folding. The igneous rocks have proved themselves more resistant to weathering, and most of the higher points, such for example as Snowdon and Cader Idris, mark the outcrop of one or more masses of igneous rock. As one passes from north into central Wales, the igneous masses become less numerous, and this is one reason for the less rugged relief of central Wales. The age of the folding of the rocks, too, becomes successively younger as one goes towards the south. Whilst north and central Wales, which at that time were probably continuous with south-eastern Ireland, formed the land mass which we have already called St. George's Land in Carboniferous times, south Wales was occupied first by the Carboniferous Limestone sea, then by the fringing swampy lands on which grew the Coal Measure forests. Coal Measures were laid down over a huge area in South Wales, and at the end of the Carboniferous period were folded by the Carbo-Permian or Armorican earth movements. These earth movements resulted there in folds with an east–west trend, thus causing the great coal basin of the South Wales Coalfield. It would seem that the Armorican earth movements were unable to fold the already highly complicated and hardened masses of North Wales, and that the earth-building waves broke against this resistant mass both along its southern and eastern sides. Thus there are east–west folds in the south, but north–south folds in the east. Some of the latter are remarkably sharp, and one forms that curious line of hills, the Malvern Hills. The Malvern Hills folds are

typical of the group with a north–south trend which is sometimes referred to as the Malvernian group. Where the north–south and east–west folds cross, small nodes and basins were formed of which the Forest of Dean coalfield is an excellent example.[1]

It will be seen that a triangular space remains between the east–west Carboniferous folds of South Wales, the north-south Malvernian folds of the eastern margin, and the south-west to north-east Caledonian folds of central Wales. This triangular space is occupied mainly by rocks of Old Red Sandstone age. Where the rocks consist mainly of hard red sandstones and conglomerates, they give rise to high moorland country such as that of the Brecon Beacons, including indeed some of the wildest moorland country in the whole of the British Isles. Where the Old Red Sandstone consists, on the other hand, of comparatively soft red marls lower ground has resulted, in particular the famous fertile lands of central Hereford which is thus a basin lying within the bounds of the Welsh massif. Even here thin irregular limestone bands (cornstones) have resulted in a diversified relief. An attempt has been made in Fig. 27 to divide the Welsh massif into its smaller constituent regions.

(6) **The Peninsula of Devon and Cornwall.**—The south-western peninsula is the third of the masses of ancient rocks which occur on the western side of England and Wales. It is very different in character from the Lake District massif, and also from the Welsh massif. The folding of the rocks is very complicated and took place, for the most part, during the Carbo-Permian or Armorican earth movements, and the strike of the folds is east to west. During the folding there was an intrusion of large granite masses. Thus from early Permian times onwards, as already pointed out, there must have been great east and west mountain chains separated by deep rock-girt basins in which the Permian and Triassic rocks were laid down. But through the long ages since, denudation has been active, and the ancient mountain chains have been worn down until now there are certainly no rugged mountains in Devon or Cornwall. Instead there is an elevated plateau rising to its greatest heights either where the old rocks are very hard or tough, as in Exmoor, or where the granite masses have offered a greater resistance to denudation than the surrounding sediments, as they have in Dartmoor and Bodmin Moor and other areas. The south-western peninsula also seems to have undergone at least since mid-Tertiary times a general though intermittent uplift, so that at the present day we may best describe the area as a succession of plateaus or platforms generally believed to be of marine origin—plateaus which meet the present ocean in the long succession of rugged cliffs, so characteristic of the coasts of Devon and Cornwall. It should be

[1]Still better shown in the complicated Bristol district, and the Mendips.

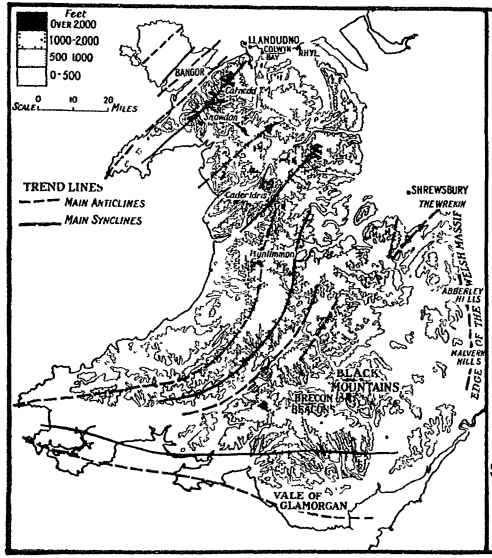


FIG. 26.—Physical map of Wales showing trend-lines

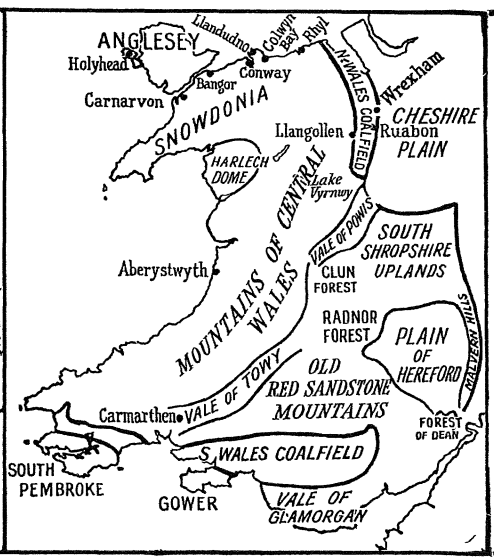


FIG. 27.—Wales, showing a division into physiographic regions

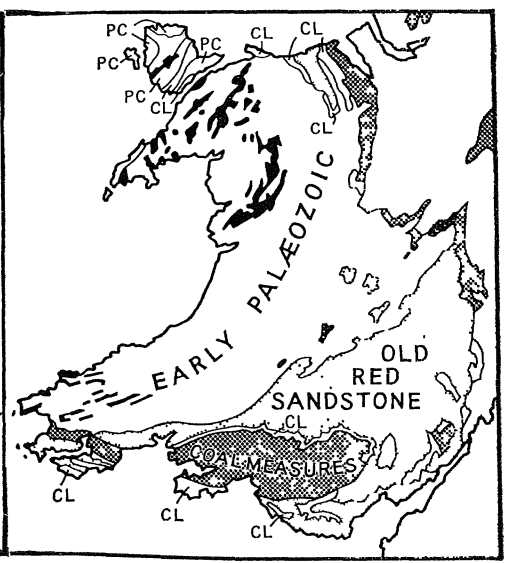


FIG. 28.—Geological map of Wales

Black=igneous rocks; PC=Pre-Cambrian, CL=Carboniferous Limestone

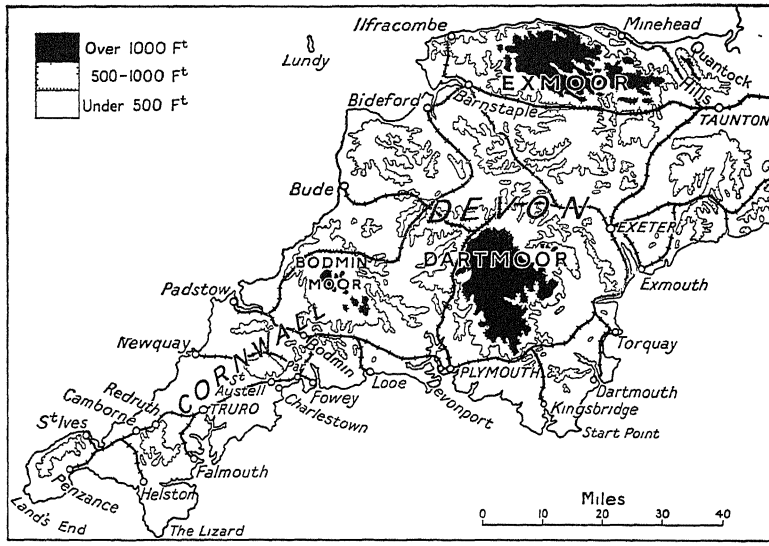


FIG. 29.—Physical and general map of the South-Western Peninsula

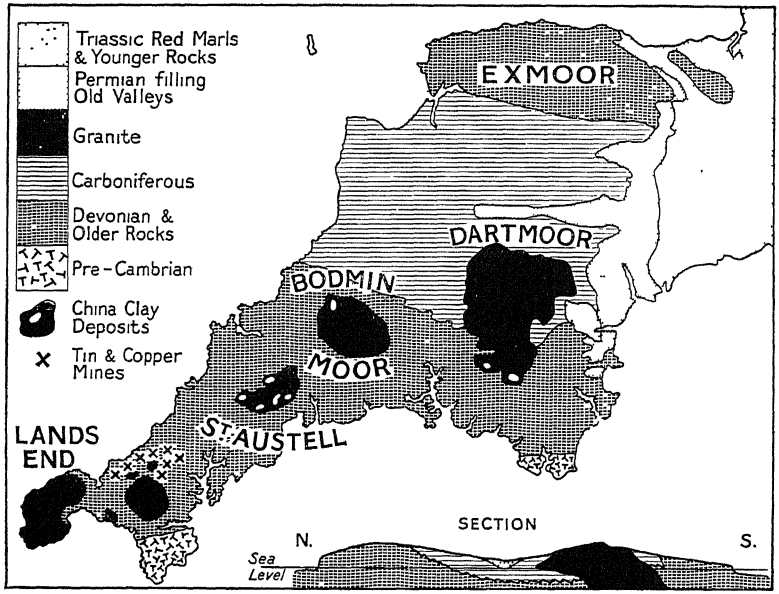


FIG. 30.—Geological sketch map of the South-Western Peninsula

A comparison with Fig. 29 will suggest the correlation between the granite masses and higher areas of the plateau surface—with Exmoor as an exception. The section is from Exmoor through the Dartmoor granite

mentioned that a part of western Somerset (the Quantocks) is also included within this region. The higher levels are occupied by moorlands, but much of the remainder is cultivated, since the Devonian and Carboniferous rocks break down into a moderately rich soil. The comparatively mild climate, specially of the more sheltered valleys, is responsible for the special vegetation and utilisation features of these valleys both in Devon and Cornwall.

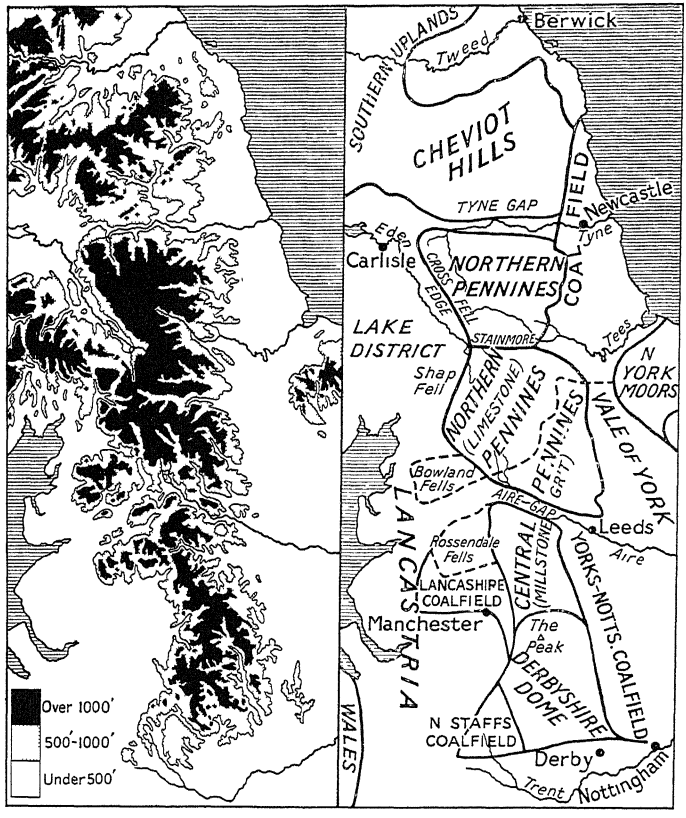


FIG. 31.—The Pennines

(7) **The Pennines.**—The Pennines, or the "Backbone" of England, are sometimes wrongly referred to as a chain of mountains. This term is entirely incorrect, and it is not wise to apply even the term "range" to them. It is much more suitable that they should be referred to as the Pennine Upland. It is probable that Coal Measures were deposited, as we have already seen, right across the north of England, and that the Pennine Uplift dates from post-

Carboniferous times, that is from the Carbo-Permian earth movements. The Pennines are often represented in diagrammatic sections as if they were a simple anticline. Broadly speaking, however, the fold, if such it may be called, is defined by a series of great faults on the west, and consequently the highest portion of the Pennines is usually the western margin overlooking the lowlands to the other side of the boundary faults. The Carboniferous Limestone and Millstone Grit rocks which make up the bulk of the moor-covered Pennine Uplands are themselves but slightly folded, often almost horizontal, but towards the east they take on a general dip towards the North Sea, so that on the eastern side the Pennines fade gradually

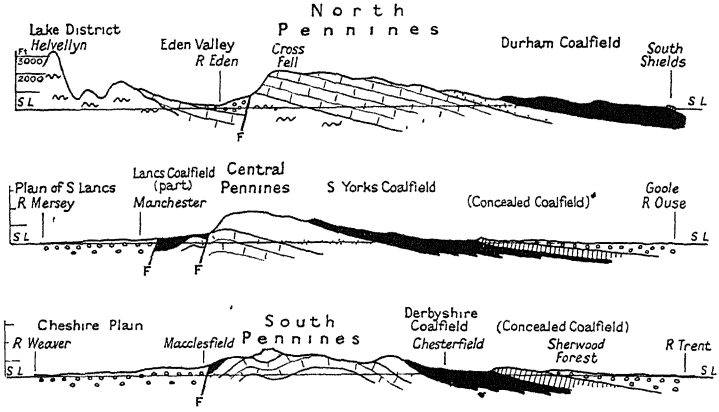


FIG. 32.—Sections across the Pennines

The geological formations shown are: Lower Palæozoic Slates (wavy lines), Carboniferous Limestone (brickwork), Millstone Grit (dots), Coal Measures (black), Magnesian Limestone (vertical lines), Trias (circles). Note the asymmetrical character of the uplift and the variation in structure from north to south.

into the lower ground bordering the North Sea itself. Important transverse valleys divide the Pennines into four blocks; these are shown on Fig. 31 in relationship with the main outcrops of Carboniferous Limestone and the Millstone Grit. In the north the Cheviot Hills, largely built up of volcanic material, form a connecting link between the Pennines and the Southern Uplands of Scotland.

The remainder of England is occupied for the most part by lowlands, and is built up mainly of rocks younger than those which form the Highland Zone. For purposes of description, the following broad regions may be distinguished.

B. THE LOWLAND ZONE

The Triassic Plain of the Midlands.—The Midlands of England, in a somewhat restricted sense, consist for the most part of lowland, and occupy a V-shaped area. The southern end of the Pennines

fits into the centre of the "V," the left arm of which joins the lowlands of Cheshire and Lancashire, through the Midland Gap, while the right arm joins the lowlands of the Vale of York by way of the broad lower Trent Valley. Geographically the Midlands so defined may be regarded as bounded on the south-east by the first of the "scarps" which make up the scarplands of south-eastern England. On the west the Midlands stretch as far as the edge of the Welsh massif, which has already been described. The point of the "V" stretches to the Severn estuary and extends through the interesting, if complex, Bristol-Mendip region into the Plain of Somerset. The most important of the geological formations in the Midlands is the Upper Trias or Keuper Marls with the fine-grained Keuper Sandstones, which weather to a rich red soil excellent for cattle pastures and for cultivation. The Triassic Marls are very similar to the Old Red Marls of Herefordshire. Both give rise to lowlands. The Lower Trias or Bunter is a formation of sandstones and pebble beds which results in rather higher and less fertile country, such as the Cannock Chase plateau. The whole of the Trias, as already explained in Chapter II, was originally laid down in a shallow inland basin under almost desert conditions (compare the Great Salt Lake of Utah at the present day), and the Triassic deposits are found wrapping round masses of older rock which formed islands in the old lake basin. The "islands" include the small coalfields of the Midlands, and since they give rise to industrial areas in the midst of country otherwise agricultural they should be considered separately, together with the "islands" of still older rocks.

The "Islands" of Old Rocks in the Midlands.—These islands of old rock are best considered in relation to the southern end of the Pennines. Taking a point at the southern end of the central limestone core of the Pennines, just west of Derby, it is possible to draw radiating lines each passing through one of the old islands. This has been done in Fig. 33.

(*a*) *Charnwood Forest* lies to the south-east of the Southern Pennines. It consists of very ancient (Pre-Cambrian) rocks, though all but the highest hills of the ancient island have been covered with Triassic deposits. But the geology makes Charnwood Forest quite different from the surrounding country. There are pretty wooded hills and winding leafy lanes, and the whole area is one of the playgrounds of the Midlands. Some of the old rocks are quarried for road metal, which is used all over southern England.

(*b*) *The Leicestershire Coalfield* lies next to Charnwood Forest on the west. It is one of the few coalfields of England which has not given rise to an extensive industrial area. The coalfield and Charnwood Forest form an upland area which has been called (as on Fig. 34) the Ashby-Charnwood Plateau.

(*c*) *The Nuneaton Ridge*, a narrow ridge of ancient rocks including the Cambrian Hartshill Quartzite, lies almost due south of Derby.

(*d*) *The Warwickshire Coalfield*, sometimes called the Nuneaton Coalfield, lies to the west of the Nuneaton Ridge, just as the Leicestershire field lies to the west of Charnwood Forest.

(*e*) *The Lickey Hills.*—Due south from the centre of the Pennines

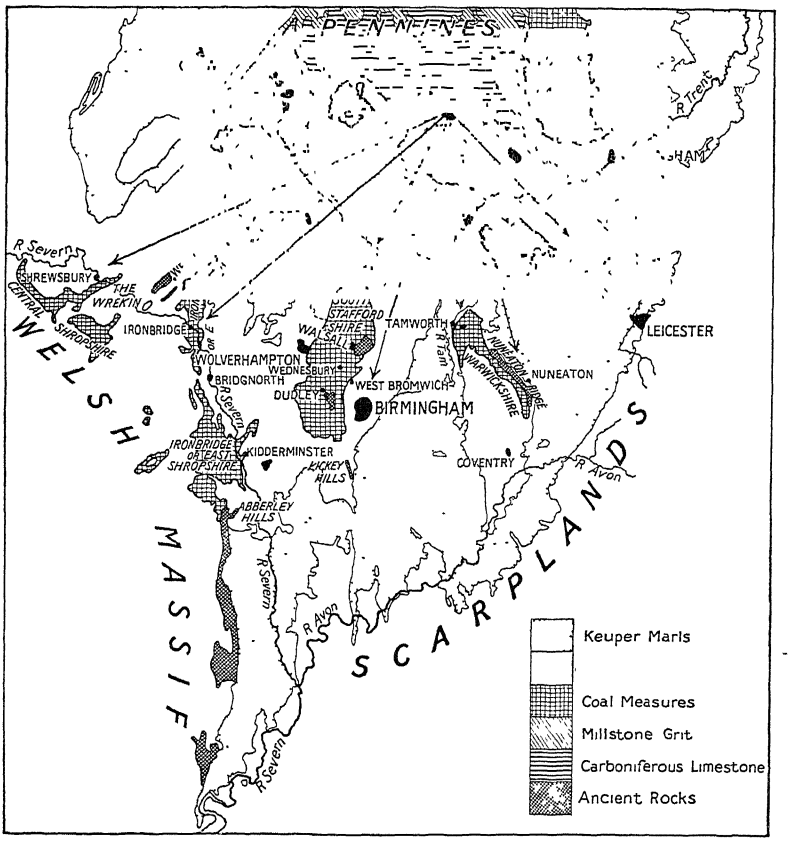


FIG. 33.—The ancient islands of the Midlands

the line passes nearly through Birmingham and then through a very small island of ancient rocks comparable with the Nuneaton Ridge—these are the Lickey Hills.

(*f*) *South Staffordshire Coalfield.*—This large and important coalfield lies immediately to the north-west. The northern part is a broad plateau, continued northwards by Bunter Sandstones and known as "Cannock Chase." Associated with the southern part of this coalfield is the famous "Black Country." A hard breccia at

the top of the coal measure sequence gives rise to the ridge of the Clent Hills.

(*g*) *The Ironbridge and Forest of Wyre Coalfield* (East Shropshire Coalfield) is a long, narrow coalfield stretching southwards from Wellington and lying along the edge of the Welsh massif. It is cut through by the gorge of the Severn.

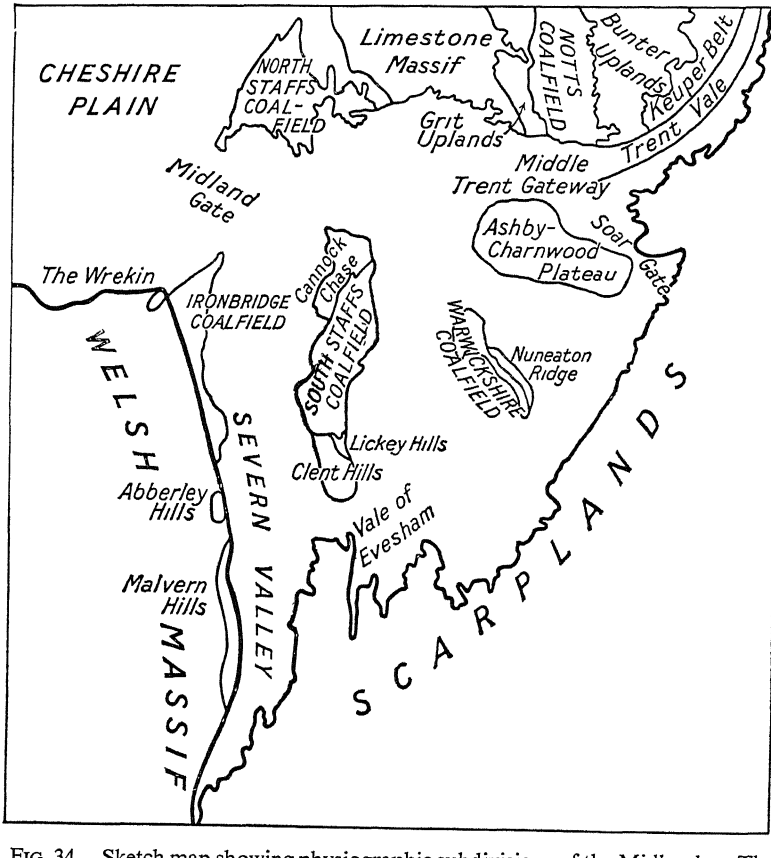


FIG. 34.—Sketch map showing physiographic subdivisions of the Midlands. The north-eastern part is after Professor H. H. Swinnerton

(*h*) *The Wrekin*, a hill of ancient rocks near Wellington, has already been mentioned as part of the outer rampart of the Welsh massif. It is part of the area of old rocks which occupies central Shropshire.

Having now dealt with the islands of old rocks which give rise to most of the industrial areas of the Midlands, it remains to note a few points about the surrounding regions of Triassic rocks.

The Bunter Sandstones and Keuper Sandstones, as already

noted, coincide with low uplands, the Keuper Marls with low ground, gently undulating but otherwise rather featureless. It must be remembered that over very many areas the underlying solid rocks are masked by the glacial drifts.

To the south-east the Keuper Marls are succeeded by the Rhætic and Liassic rocks. Unless the Rhætic or lower Lias contain hard or resistant beds sufficiently important to give rise to a scarp there is little to mark the junction. Thus the Vale of Evesham is partly on Keuper, partly on Lias; so also is the Vale of Berkeley.

The Plain of Lancastria.—The plain of Lancastria forms a continuation of the Midland Plain through the Midland Gap or Midland Gate. It occupies the northern half of Shropshire, nearly the whole of Cheshire and that part of Lancashire which lies between the Pennines and the Irish Sea. There are two broad tongues of moorland, called respectively Bowland "Forest" and Rossendale "Forest," which extend westwards from the Pennines into Lancashire and which coincide with outcrops of Carboniferous Rocks (Millstone Grit and Lower Coal Measures). Elsewhere Lancashire is an undulating lowland: again, where Bunter Sandstones outcrop there may be low hills, where the Keuper Marls are at the surface true lowland prevails. The actual character of the surface, however, depends largely on the thickness and type of the mantle of glacial deposits. Physically the plain of Lancastria lies between the Welsh massif and the Pennines: on the west the undulating country of the North Wales Coalfield forms a transitional belt; in the east the coal measure country of the North Staffordshire Coalfield forms another transitional belt.

The North-Eastern Lowlands of Nottinghamshire, Yorkshire, Durham, and Northumberland. On the eastern side of the Pennines, and thus corresponding to the Plain of Lancastria on the west, is a broad belt, mainly of lowland. The Carboniferous Limestone and Millstone Grit formations which make up the bulk of the Pennines dip eastwards, and are succeeded in turn by the Lower Coal Measures, the Middle and Upper Coal Measures, the Magnesian Limestone and higher Permian beds, the Bunter Sandstone and the Keuper Marls. In general terms each succeeding formation gives rise to its own characteristic type of country. Thus there is a succession of physiographic zones roughly parallel to the Pennines. The Lower Coal Measures give rise to rather barren land with patches of moorland separated from one another by river valleys. The more fertile country of the Middle and Upper Coal Measures has a gentler relief, but resistant beds may form westward facing scarps (see Fig. 218). Tongues of lowland extend into the heart of the Pennines along the famous "Yorkshire Dales"—particularly those formed, from north to south, by the Swale, Ure, Nidd, Wharfe, Aire, Calder, and Don. The Magnesian Limestone usually forms a distinct west-

ward facing scarp, often with attractive cliff scenery, especially at those places where the scarp is cut through by rivers. The Bunter Sandstone, as in the Midlands, coincides with sandy, rather elevated tracts, infertile and hence often well wooded as in the well-known Sherwood Forest. Occasionally marked bluffs are found, such as that on which Nottingham Castle is situated. The final belt is that of the Keuper Marls and is the lowland belt which stretches from the mouth of the Tees to the Trent Vale of Nottinghamshire, but the Keuper Marls are masked by superficial deposits over large areas, particularly over that huge tract known as the Vale of York, and the interesting area of the Isle of Axholme.

The Bristol-Mendip Region.—To the south-west the Midland Plain narrows and passes first into the Vale of Gloucester and then into the Vale of Berkeley between the Forest of Dean or the Severn on the west, and the fine scarp of the Cotswolds on the east. But farther southwards, in what may be called the Bristol-Mendip Region, the plain disappears. Its place is taken by country of varied relief lying between the Severn and the westernmost of the Jurassic scarps. This region repeats, on a smaller scale, the features of parts of the Midlands. It really consists of "islands" of old rocks wrapped round by the softer Triassic and Liassic deposits. But there are several points of difference: the islands are relatively larger and more numerous, the amount of low ground correspondingly small. The islands, too, are of rocks of varied age; there are the large Carboniferous Limestone masses of the Mendip Hills, and the important coal basins, as well as quite tiny patches of Silurian, Old Red Sandstone and Carboniferous Limestone. The "islands" are remnants of Armorican folds, and it is in this region that the north–south Malvernian folds cross the more normal east–west folds. Thus some of the old blocks are elongated in a north–south direction, such as the Tortworth Ridge north of Bristol and the Carboniferous Limestone edges of the Kingswood coal basin. In the Mendip Hills a succession of east–west folds *en echelon* has resulted in a broad upland trending from west–north–west to east–south–east.

The Plain of Somerset.—In some ways this plain resembles that of the Midlands from which it is separated by the Bristol-Mendip region. The Vale of Taunton Deane is thus a Keuper Marl lowland, but the great feature of Somerset is the very extensive plain, almost at sea-level and liable to extensive floods, which lies between the Quantock Hills and the Mendip Hills, and which is interrupted only by the narrow Liassic ridge of the Polden Hills.

The Jurassic Scarplands.—The Jurassic rocks of Britain crop out over a belt of varying width extending from the Dorset coast to the north Yorkshire coast. Over large areas the beds dip to the south-east or east, and so give rise to a succession of hills or ridges where the harder or more resistant beds crop out, and valleys

or negative relief where the softer or more easily eroded rocks occur. The hills usually have a steep scarp slope on the one side, generally to the north-west, and a long gentle dip slope on the other. Whilst the general arrangement is that suggested in Fig. 36, it is a mistake to imagine a continuous Jurassic limestone scarp running right across the country. The hill-belts and scarps are not formed by a single rock formation, but by different rock groups in different areas. The scarps swing about in different directions, die away, and

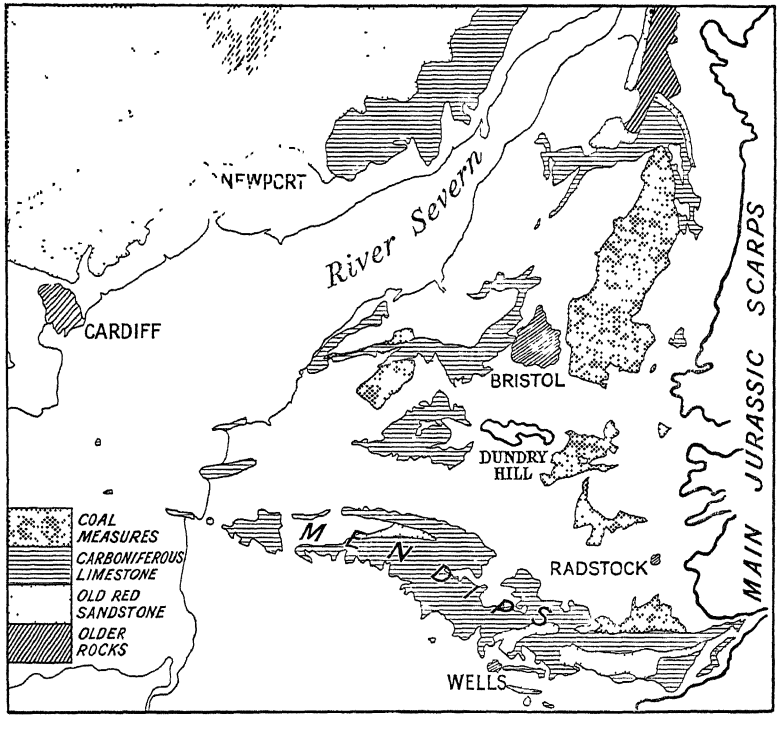


FIG. 35.—The Bristol-Mendip Region, showing the islands of old rocks. The unstippled land areas are Triassic and lower Jurassic rocks and recent deposits

start again. In some parts of the Midlands, the dip slope of the resistant beds is so slight that the structure of the country becomes that of a dissected plateau. Thus the Jurassic scarps are not nearly as constant as that of the Chalk.

In the first place the Jurassic rocks were laid down in shallow water, and consist of a varied series of clays, fine and coarse sands, sandstones and limestones. Some of the latter are oolitic, but the importance of the oolitic limestones has been over-emphasised as a result of their economic value as building stones or for lime. The

variability of the Jurassic succession was enhanced by the presence within the sea of three axes of uplift which, by separating the sea into four different basins, allowed a different succession of clays, sands, and limestones to accumulate in each basin. Along the axes, which lay respectively east–west across South Yorkshire, north-west to south-east across Oxfordshire and west-north-west to east-south-east along the line of the Mendip Hills in Somerset, the whole Jurassic sequence is naturally thin.

An attempt has been made in Fig. 37 to show the actual position

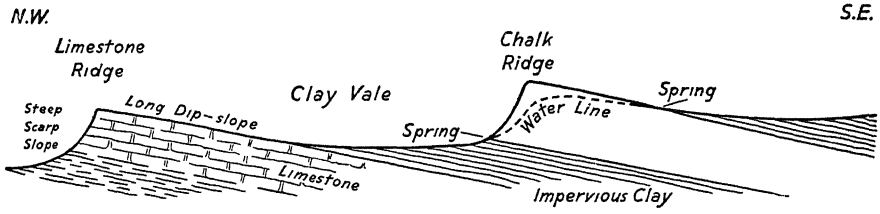


FIG. 36.—Diagrammatic section illustrating the succession of clay vales and limestone or sandstone ridges found in the south-east of England

of the true scarps.[1] Those shown have a minimum slope of 1 in 10. The scarplands may be divided as follows:

(1) *The Northern Basin of Deposition.*—The Cleveland and Hambleton Hills of North Yorkshire. Here the wavy dissected scarp, 600 feet high, with its deep valleys and its plateau-like surface, is formed by thick sandstones of Inferior and Great Oolite Age, accentuated by the resistant nature of the underlying Upper and Middle Lias beds which form the lower portion of the cliff. There are also tabular hills of Corallian rocks.

(2) *The Market Weighton Uplift* of South Yorkshire. The thin Jurassic rocks are overlapped by the Chalk and there is no Jurassic scarp.

(3) *The Central Basin of Deposition*—in Lincolnshire and Northamptonshire.

(*a*) In Lincolnshire the remarkable Lincoln Cliff, from 100 to 200 feet high, runs north and south in an almost straight line, broken only by the Witham Gap on which Lincoln is situated. It is formed by the Lincolnshire Limestone (Inferior Oolite); to the west is the low ground on soft Liassic Clays; to the east low ground again.

(*b*) In south Lincolnshire and Leicestershire there are three distinct scarps. The Rhætic and Lower Lias limestones form a small ridge, of no great extent, some 10 miles west of Grantham. Eastwards are wide lowlands on Lower Lias Clays; then, beginning near Caythorpe, and increasing in height as it swings south-westwards to form the Melton Mowbray ironstone ridge, is the scarp, about 150 feet high, formed by the Middle Lias marlstone. Farther east is the Upper Lias clay vale, then a scarp 200 feet high which marks the edge of a Lincolnshire limestone plateau. The last scarp continues, rather

[1] For full details, see S. H. Beaver, "The Jurassic Scarplands," *Geography* XVI, 1931, 298–307.

more broken, south of Grantham and overlooks the Vale of Catmoss in Rutland and the Welland Valley in Northamptonshire.

(*c*) In eastern Warwickshire and Northamptonshire there are really no scarps (partly owing to Boulder Clay cover), but instead an undulating area and a watershed where a number of important streams

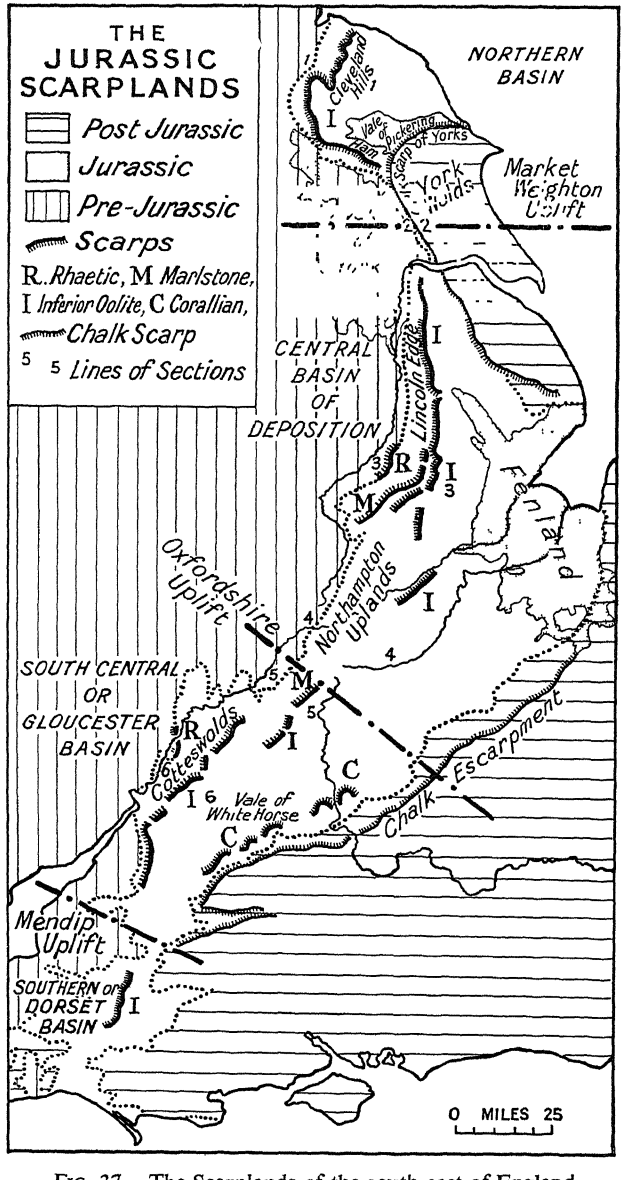


FIG. 37.—The Scarplands of the south-east of England

rise. Many of the rocks present are resistant, so the area is in the main an upland.

(4) *The Oxfordshire Uplift* in south-eastern Warwickshire and north Oxfordshire. Here the Lower Lias limestones continue to form an upland and the Marlstone makes the marked feature of Edge Hill, but the Inferior and Great Oolites are poorly developed and give rise to undulating ground.

(5) *The South-Central or Gloucestershire Basin of Deposition.*—Here the great scarp of the Cotswolds, 600 feet high, dominates the whole country. The scarp is formed in the main by the Midford Sands and

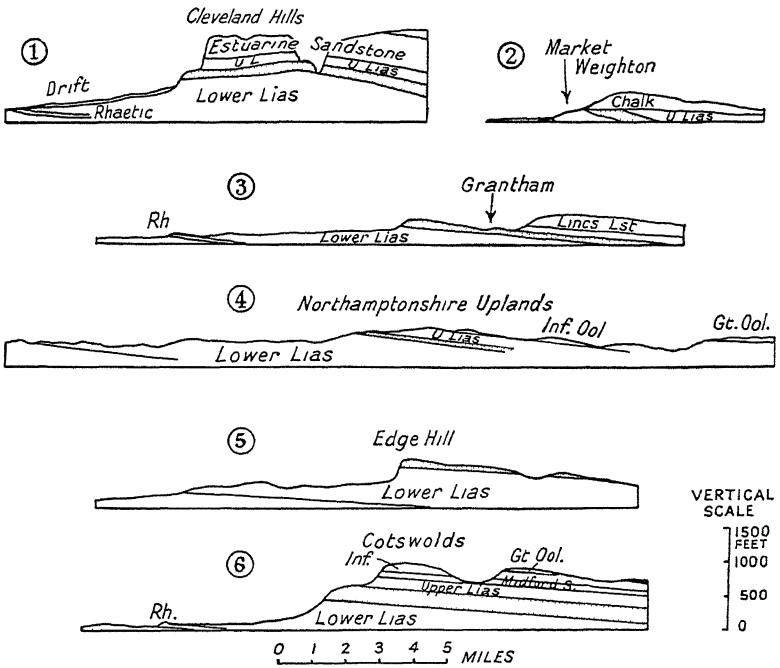


FIG. 38.—Some typical sections across the scarplands

The numbers refer to the lines of section shown on Fig. 37. Stippled band = Middle Lias (mainly sandstone and marlstone)

the limestones and grits of the Inferior Oolite, but the extensive dip slope is usually capped by the Great Oolite limestone and Forest Marble. Frequently the main scarp is "stepped," a lower step or shelf being formed by the Middle Lias Marlstone. To the west there is locally a small Rhætic scarp; to the east the Cotswolds slope gradually towards the great Clay Vale (including the Vale of the White Horse) and only in some places is the eastern side of the Vale interrupted by a small scarp formed by the Corallian.

(6) *The Mendip Uplift.*—The Oolitic escarpment ceases to be clearly recognisable south of Bath. All the Jurassic divisions tend to become thin and to lose their normal lithological character towards the Mendips where there was an axis of uplift during the time of their deposition.

(7) *The Southern or Dorset Basin of Deposition.*—Southwards from the

Mendips the Jurassic succession resumes again its normal features (in the Dorset basin of deposition), and the Oolites, together with the Upper Lias, form a prominent escarpment of Cotswold type separating the Vale of Blackmore on the south from the Somerset lowlands on the north. In detail, the area is very complex as there are no less than eleven different resistant beds which in places form scarps. Farther south the area is dominated by the Upper Greensand scarp of the Blackdown Hills.

It will be clear that the great Clay Vale is formed in the main by the clays of the Upper Jurassic. In Yorkshire it is represented by the old glacial lake basin of the Vale of Pickering (on Kimmeridge Clay). The Lincoln Vale is on the Oxford and Kimmeridge clays, and broadens out southwards to the great flat of the Fens where the solid geology is completely masked. Beyond this is the clay vale drained by the middle portion of the Ouse, on which stands Bedford. A low divide separates this area from the wide clay Vale of Aylesbury in the drainage basin of the Upper Thames. This Vale owes its existence to the thick and almost continuous succession of Upper Jurassic and Lower Cretaceous Clays. It is continued westwards in the Vale of Oxford, and the Vale of White Horse, but here the clay vale becomes interrupted by the Corallian scarp, and there are local features, such as Shotover Hill, formed by Portlandian rocks.

The accompanying sections illustrate not only the scarp-forming formations, but also the general Jurassic sequence.

The Chalklands.—That fine white limestone known as chalk, although soft, is more resistant to weathering than the clays or sands which underlie it and the more recent sediments by which it is sometimes succeeded. As a formation it is thick—600 to 1,000 feet generally—and varies but little from Yorkshire to the Isle of Wight. Consequently it gives rise to a scarp, in general westward facing, which is both more conspicuous and more continuous than the scarps formed by the Jurassic rocks. Only rarely—as in the East Anglian Heights—is this feature inconspicuous, even more rarely almost absent. The dip slope of the chalk is characteristically "rolling" country and innumerable dry valleys are a constant feature. Where the chalk is almost horizontal large stretches of rolling downland (typified by Salisbury Plain) result; where the dip of the beds is steep there is little difference between the dip slope and the scarp slope and "hog's back" lines of hills result, like the Hog's Back between Guildford and Farnham. The belt of chalklands commences in the north in Yorkshire (where it forms the Yorkshire Wolds). It is interrupted by the Humber and forms the ridge through which that river passes just before reaching Hull. Southwards are the Lincolnshire Wolds, as far as the second interruption caused by the Wash. In both the Yorkshire and Lincolnshire Wolds the character of the chalklands is modified by a thick mantle of glacial deposits. From the chalk cliffs of Hunstanton in Norfolk, the scarp is represented

merely by low hills overlooking the Fens. In the neighbourhood of Newmarket, the chalk hills become more distinct (East Anglian Heights) and gradually the great stepped scarp of the Chiltern Hills becomes increasingly marked. The River Thames cuts through the chalk ridge by the Goring Gap. In Berkshire and northern Wiltshire the chalk outcrop broadens to form the Lambourn and Marlborough Downs. In this part of England certain beds below the chalk, especially the Upper Greensand (here a close-grained loamy clay), assume a special significance. The important Vale of Pewsey is floored by the Upper Greensand and the morphological features of this Vale are particularly interesting. To the south is the great stretch of Salisbury Plain. The chalk downs extend into Dorset. From here westwards an important feature is formed by the Greensand deposits—here with more resistant beds—which give rise to the Blackdown Hills.

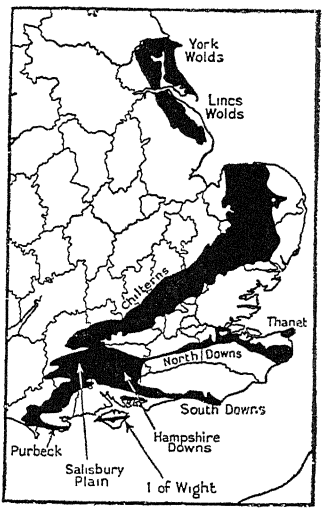


FIG. 39.—The Chalklands of England

Along the south coast tracts, Britain was considerably affected by the Alpine earth movements, and the highly folded chalk—almost vertical in places—gives rise to a ridge through the Isle of Purbeck and then the Isle of Wight.

To the north and south of the Weald are the North Downs and South Downs respectively (see below, p. 52).

The Weald.—Originally the whole of south-eastern England was covered with a thick mantle of chalk, and the uplift of the Wealden dome took place during the Alpine earth movements. The crest of the dome, which is elongated from east to west, trends on the whole in that same direction, but the axis curves towards the south-east when followed over the Strait of Dover into the northern part of France. The Weald of Kent, Surrey, and Sussex forms classic ground in many respects, for it was here that W. M. Davis [1] studied the evolution of the river system and applied the following terms which are now universally used. From the central ridge of the upfold, the rivers drain off to north and to south. Their direction was a consequence of the structure of the ground, and hence such streams are called "consequent." As the rivers and other agents of denudation continued their work so the chalk was entirely removed over the central area and the underlying rocks were exposed. The

[1] "The Development of certain English Rivers," *Geog. Jour.*, V, 1895, 127.

softer beds, such as the clays, were worn away by streams running into the consequent rivers at right angles. These streams developed subsequently to the earlier ones and so are called "subsequent." Still smaller streams, which joined these at right angles in such a way that their direction of flow was often opposite to that of the consequent streams, are known as "obsequent." The rocks underlying the chalk in the Weald belong to the Lower Cretaceous Series, and there are alternating soft, or easily eroded, beds, mainly clays, and harder, or more resistant beds, mainly sands and sandstones. One thus has a repetition in miniature in the Weald of the features of the scarplands of England, with each successive ridge showing a scarp facing towards the centre, as suggested in Fig. 40. At a late stage in the history of the area, the Strait of Dover was cut and occupied by the sea across the eastern end, so that the extreme east of the Weald is actually in France. In the heart of the Weald as it is to-day is a group of sandy beds forming hills once covered with

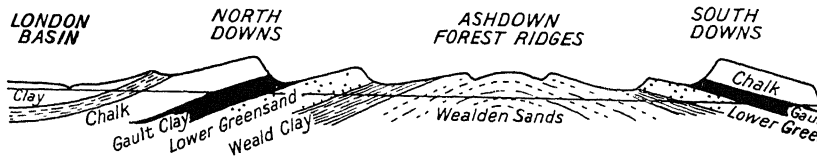


FIG. 40.—Diagrammatic section across the Weald from north to south

thick forest, and so often known as the Forest Ridges. Surrounding these hilly central tracts is a belt of lowland where the Weald Clay and certain other clayey beds are found, then a belt of hills formed by the harder beds of the Lower Greensand, then again a valley, called Holmesdale in Surrey and Kent, which marks in the main the position of the soft Gault clay. Then comes the main ridge of all, formed by the chalk, well known as the North Downs in the north and the South Downs in the south. The Downs present a steep scarp slope inwards towards the heart of the Weald, and then a long gentle dip slope in the reverse direction. Sometimes the dip of the chalk is steep, as in the famous Hog's Back west of Guildford, and the apparently simple structure shown in the diagram may be complicated locally, especially where the escarpments are "stepped" and certain horizons, *e.g.* the Lower Chalk, give rise to platforms. Although the Weald is thus a well-marked region, it will be seen that it comprises a number of different parts, which may now be separately considered.

(*a*) *The Forest Ridges or the High Weald*, usually built up of various groups of sand, particularly the Ashdown Sands, the Tunbridge Wells Sands, and the Hastings Sands, once densely forested and important for the supply of timber for charcoal for the now defunct iron industry.

(*b*) *The Weald Clay Vale*, a region of negative relief, still very wet,

mainly occupied by pasture lands with scattered remnants of the once continuous cover of damp oak woodland. It is a tract in which older settlements and villages are relatively few.

(*c*) *The Greensand Ridge* or the tract of well-drained land with numerous springs on the flanks. Sometimes the land is highly cultivated, but where the sand is coarse the soil may be poor and there are wide stretches of heathland. The Greensand ridge passes towards the western edge of the Weald into a broad tract of undulating, dry, heathy country which has been called the Western Heights. It should be noted that the Lower Greensand does not give rise to a distinctive region on the southern side of the Weald.

(*d*) *Holmesdale* is another tract of damp clay lands, but at the foot of the downs there is usually a strip where the Upper Greensand and Lower Chalk outcrop and where there are good, rich mixed soils, largely cultivated.

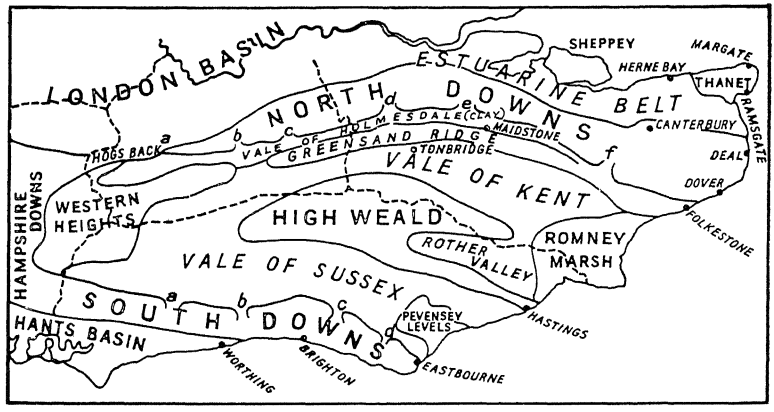


FIG. 41.—The minor regions of the Weald

(*e*) *Romney Marsh* is a separate area within the Weald, now drained and occupied by pastures, whilst *Pevensey Marsh* is a similar area though its utilisation is different (see p. 208).

Strictly speaking the Weald may be regarded as limited by the main crest of the chalk scarp, but it is often convenient to consider as belonging to it the chalk downs as well. When one remembers that the chalk ridge maintains an average elevation of 500 to 700 feet, and that there is a drop of 400 feet or more to the Gault Clay Vale, the importance of the gaps through the ridge is at once apparent. Along the North Downs the chief gaps and gap towns from west to east are (the letters refer to Fig. 41):

(*a*) The Wey Gap—Guildford.
(*b*) The Mole Gap—Leatherhead and Dorking.
(*c*) The Merstham Dry Gap—Redhill and Reigate.
(*d*) The Darent Gap—Otford and Farningham.
(*e*) The Medway Gap—Rochester.
(*f*) The Stour Gap—Canterbury.

Along the South Downs are:

(*a*) The Arun Gap—Arundel.
(*b*) The Adur Gap—Steyning.
(*c*) The Ouse Gap—Lewes.
(*d*) The Cuckmere Gap.

Apart from the features associated with the normal scarplands there are morphological characters of great interest in the Weald in the presence of platforms, probably cut by the Pliocene—the last sea to occupy this part of Britain.

The London Basin.—The London Basin is both a geographical and a geological unit. Geologically, it is a broad synclinal basin

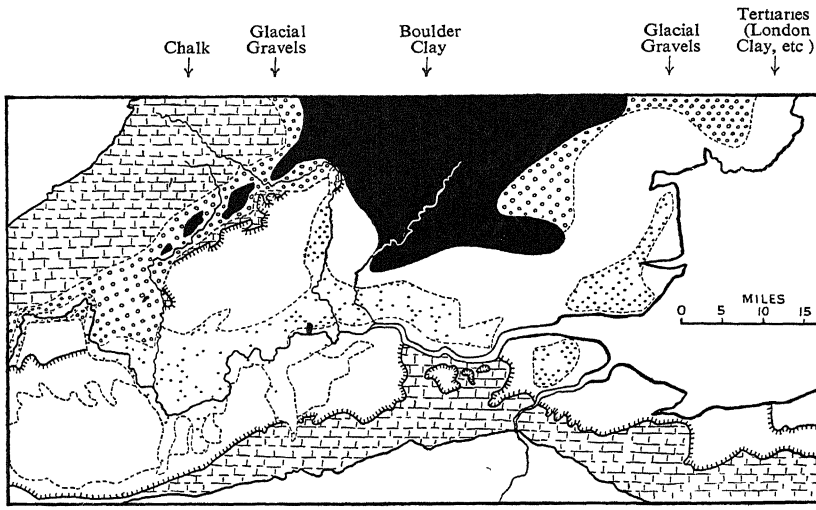


FIG. 42.—The geology of the London Basin (simplified)

Lightly dotted area = river gravels, for alluvium, see dotted area on Fig. 43.
(*After S. W. Wooldridge*)

with a clearly defined chalk rim and a central portion occupied by sands and clays of the Tertiary sequence, by gravels of varied origin, and by alluvium. The chalk which underlies the London Basin in turn rests directly, or with but a small intervening thickness of older deposits, on the ancient Palæozoic platform which, like its analogues in South Wales or Northern France, is highly folded and fractured. It is probable that renewed movements along the folds and fractures of the Palæozoic platform have been responsible for the existence in the London Basin of minor structures. The London Basin, a syncline as a whole, is not symmetrical. Its axis is towards the southern edge, and it is to be noted that it is along this line that the lower River Thames flows. Then there is quite an important fold in the centre with an east–west trend, sometimes known as the

Thames Basin or the London Basin Anticline. These minor structures, combined with the very varied character of the young sedimentary rocks which fill in the basin, are responsible for its very varied morphological character. It has, accordingly, been divided into minor natural regions, mainly on a geo-morphological basis, by Professor S. W. Wooldridge.[1] Two maps are here reproduced from Professor Wooldridge's account, the one showing the position of the main drift deposits, and the other a suggested regional subdivision of the basin. These two maps must be left to speak for themselves. They should be used when studying in detail the position of London itself.

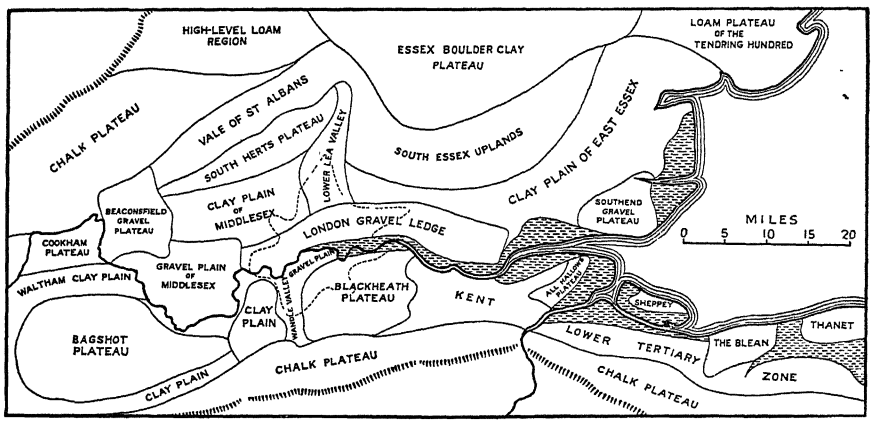


FIG. 43.—The minor physiographic regions of the London Basin, according to Professor S. W. Wooldridge

The Hampshire Basin.—In many ways the Hampshire Basin resembles the London Basin. There is a surrounding girdle of chalk downs and a central region of later clays and sands. Instead, however, of the basin being open to the sea to the east, its southern chalk rim has been cut through by the sea in two places—at each end of the Isle of Wight. Although strictly speaking the Hampshire Basin might be limited to the central area of Tertiary rocks, it is convenient to consider the surrounding area of chalk downs also in any general geographical consideration of the Basin. There is thus the Tertiary belt of the heart of the basin, and the surrounding chalk lands. As in the case of the London Basin, subsidiary folds occur, and one important one brings up the chalk to form the Portsdown Hill to the north of Portsmouth (see Fig. 44). The Tertiary belt differs from that of the London Basin in the rather larger proportion

[1] "The Physiographic Evolution of the London Basin," *Geography*, XVII, 1932, 99–116.

of coarse or mixed sands. These are especially important in the south-west, where the New Forest is found on sandy areas of this character. The more varied of the Tertiary rocks give rise to sandy and loamy soils suitable for mixed farming, and have a low but varied relief. The southern rim of the Hampshire Basin is formed by a sharp fold of chalk which cuts across the Isle of Wight, following its longer axis. To the south of this central ridge in the Isle of Wight there are early Cretaceous rocks, giving rise to varied

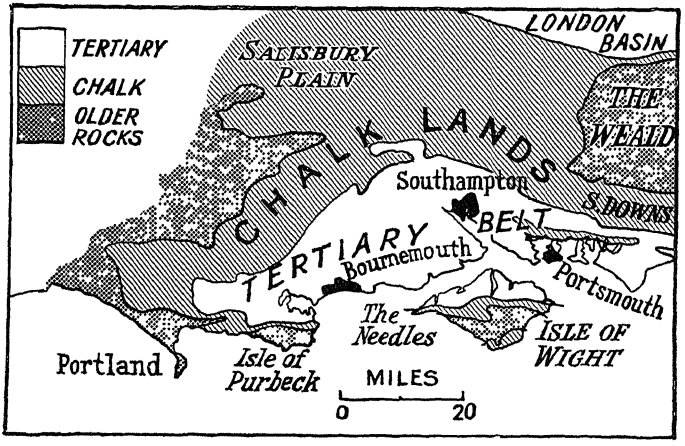


FIG. 44.—The Hampshire Basin

country, repeating on a small scale some of the features of the Weald. In the so-called Isle of Purbeck still older rocks appear, and one sees part of the Jurassic sequence of the Jurassic scarplands.

East Anglia.—East Anglia corresponds roughly with the counties of Norfolk and Suffolk. Chalk underlies most of the western two-thirds of this tract and later Tertiary rocks the remainder, but the whole tends to be so thickly covered with glacial and other deposits that East Anglia is very far from resembling the well known chalk downland. At the present day it is difficult to realise the former isolation of East Anglia. It is bounded on the north and east by the sea. To the south it stretched as far as the once thickly forested damp lowlands of Essex; on the west lay the impassable marshes of the Fenlands, and it was only to the south-west that East Anglia could be approached along the comparatively dry route afforded by the chalk country of the East Anglian Heights. Though the former isolation has disappeared, East Anglia remains a remarkable geographical entity. The character of East Anglia varies mainly according to the nature of its surface deposits. The whole is a low plateau with an undulating surface, often indeed

almost flat, and in which those towns and villages situated along the river courses tend to be hidden, as, for example, in the case of Norwich. A special feature of interest is that area known as the Broads—wide stretches of shallow water, where the rivers have been ponded back by the formation of bars preventing the free flow of their waters to the North Sea. As East Anglia is mainly agricultural, its division into sub-regions will be considered relative to agriculture.

IRELAND

The geography and natural regions of Ireland have been reserved for special treatment in connection with agriculture (see Chapter XXIX), but it may be noted here that its physiographic units connect very closely with those of England and Scotland. In the north-west there are masses of ancient metamorphic rocks which form a continuation of the Highlands of Scotland. In the north-east there is the natural continuation of the Southern Uplands of Scotland. Between the two there should be a western extension of the Midland Valley of Scotland, but this actually is obscured by the huge spread of lava which makes up the so-called Antrim Plateau, a saucer-shaped basalt plateau with the large but shallow Lough Neagh in the centre. The Mourne Mountains are formed by a mass of granite intruded into rocks which are a continuation of the Southern Uplands of Scotland. The south-east of Ireland is occupied by the Wexford Uplands and the Wicklow Mountains. Doubtless the Wexford Upland area was formerly continuous with the main mass of Wales with which it is geologically and structurally allied, whereas the Wicklow Mountains represent an enormous mass of granite, the largest in the British Isles. South-western Ireland is characterised by a succession of sandstone ridges and limestone valleys. The sandstone is mainly of Old Red Sandstone age, the limestone is the Carboniferous Limestone. The folding is Armorican; the folds are not quite east and west, the general trend being from west-south-west to east-north-east. The heart of Ireland is occupied by a great plain—the Central Plain—represented on geological maps as consisting of an enormous mass of Carboniferous Limestone. Through this there appear isolated mountain masses consisting either of older rocks, which appear in the form of anticlinal masses from beneath the limestone, or which represent the remnants of younger rocks of Coal Measure age. Actually the Carboniferous Limestone in the heart of Ireland is very rarely seen. It has been covered to a great depth, either by a mask of bog and peat or by sands, clays, and other deposits which were left behind during the retreat of the great ice sheet.

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CHAPTER IV

BRITISH WEATHER AND CLIMATE

THE variability of British weather has long been a byword and, as every holiday-maker knows, the most reliable of British weather experts are apt to be misled, at least at times, in their attempts to forecast the coming weather. Until recently atmospheric conditions at or near the surface of the earth were those which most concerned its human inhabitants. With the coming of the airplane the conditions in the higher layers of the earth's atmosphere suddenly became of considerable importance. It was during the First World War that innumerable investigations had almost perforce to be carried out in the higher layers of the atmosphere in studying the behaviour of air currents and the occurrence of "air pockets." It was largely as a result of these investigations, previously of interest mainly to the scientific meteorologist, that ideas concerning the causation of weather conditions were fundamentally changed. The old dogmatic statements of the textbooks can no longer be received, but at the same time it is not yet possible to state fully in simple terms, or with general assurance, the results of modern studies.

The old concept of the planetary wind systems placed the British Isles in the belt of the "South-West Anti-Trades," later described more accurately as the Westerlies or Variables. The development of the Polar Front hypothesis associated especially with the name of Bjerknes and his colleagues of the Norwegian school of meteorologists led to the current concepts of air-masses of differing origin and the phenomena associated with the fronts along which these air-masses meet. The development of radio has led to entirely new knowledge of the character of the upper atmosphere.

Nevertheless, we can still state simply that a number of factors have a determining influence on the character of British weather and climate. The factors may be grouped as follows:

(*a*) The shores of the British Isles, more especially the western shores, are bathed by a warm drift of water, the North Atlantic Drift, which is a continuation of the Gulf Stream. The existence of this warm drift of water has undoubtedly an important effect

[1] The authors are greatly indebted to Dr. J. Glasspoole and Professor S. W. Wooldridge for valued advice and criticism on the original draft of this chapter. Professor F. K. Hare has supplied comments on the present re-writing, and much help has been derived from Professor Gordon Manley's *Climate and the British Scene*.

in ameliorating winter conditions. To the north and north-east of the British Isles no land barrier exists to prevent the flow of water. It therefore makes its influence felt right along the coast of Norway to well within the Arctic Circle, with the result that even the Murmansk coast of northern Russia remains free from ice throughout the winter. The British Isles thus lie within the well known winter gulf of warmth and possess a milder climate than any other region in corresponding latitudes. They afford a remarkable contrast in this respect to lands such as Northern Japan or Labrador, which are situated on the eastern side of continental masses, and which are under the influence of cold ocean currents. It must be remembered that the direct effect of the warm waters themselves is much less important actually than the warmth which is communicated from the water to the

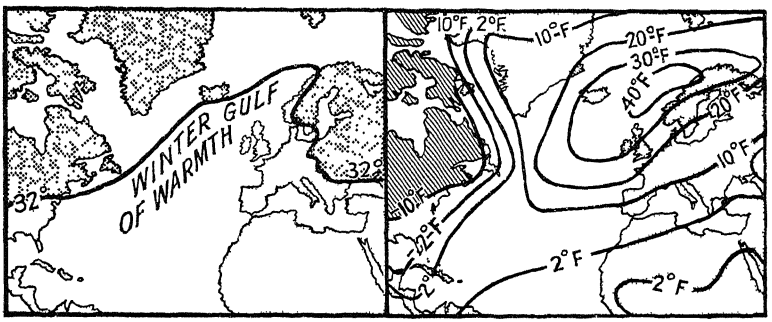


FIG. 45.—The figure on the left shows the "winter gulf of warmth" in which the British Isles lie. The isotherm shown is that of freezing point for January. The figure on the right expresses the same facts in terms of isanomalous lines. All parts heavily stippled are more than 20 degrees (F.) above the average for their latitude. Note the negative anomalies over eastern Canada

prevalent south-westerly winds. The existence of the Continental Shelf round Britain enhances the influence of the waters in that they are spread out over a wide area and thus exert a maximum influence in warming the overlying air.

(*b*) Except perhaps for certain periods in winter the British Isles lie wholly within what has long been called the westerly wind belt. There is not, of course, at any season of the year a constant westerly or south-westerly wind, although the south-westerly is the *dominant* wind in these islands. What is perhaps more important is the fact that the greater part of our weather comes from the south-west, that is from across the Atlantic, and that these islands are greatly affected by what are now described as maritime tropical (mT) air masses. The sequence of British weather depends very largely on a series of whirls and eddies in

the atmosphere (to which we give the name depressions, or "lows") and intervening wedges of high pressure which move across these islands in a direction which is generally from the south-west. By comparing the daily weather maps published by the Meteorological Office for successive days, it is often possible to trace the movements of the individual depressions across the Atlantic Ocean. On the other hand, any long range forecasting based on the weather experienced on the other side of the Atlantic is obviously liable to go wrong, since the depressions may become filled up and disappear in the course of their passage across the Atlantic or their path may lie to the north or to the south of the British Isles. The sequence of weather during the passage of a depression is well known, but changes in the rate of progression and in the intensity of depressions present considerable difficulties to the forecaster. Further reference will be made later to the character and causation of these depressions.

(*c*) The configuration of the British Isles, particularly the existence of numerous inlets, so that no part of the country is far from the sea, makes the penetration inland of oceanic influences more than would otherwise be the case. The existence of the principal hill masses of Britain on the western side of the islands, combined with the fact that the main rain-bearing winds blow from the south-west, results in a very marked difference in the amount of rainfall on the west and on the east. If it were not for this surface relief the whole of the British Isles would experience a moist climate, more like that of Ireland.

It will now be clear that the passage of depressions, or cyclones, over these islands has a dominating influence in determining the character of our daily weather. Thus the causation of these whirls in the air is a matter of some importance. According to the Polar Front hypothesis first developed by the Norwegian school a very important difference is found between cold Polar air and warm air moving from the south-west, that is from tropical and sub-tropical regions. The position and the amount of the cold Polar air varies with the seasons, and this mass of cold heavy air may be regarded as having a front, or southern

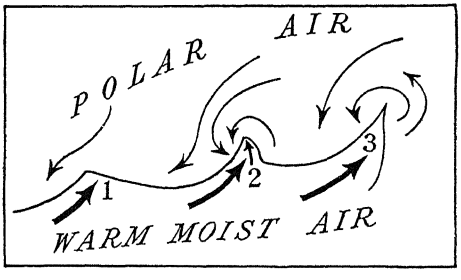


FIG. 46.—Diagram illustrating the Polar Front hypothesis of the formation of cyclones

1 = an incipient cyclone; 2 = a mature cyclone; 3 = senile or post-mature cyclone

limit, known as the Polar Front, lying normally somewhere to the north of the British Isles, not infrequently at least in the neighbourhood of Iceland. It has been suggested in winter that the Polar Front may be regarded *very roughly* as following the 32° F. isotherm. It is the friction between the current of tropical warm air and the cold, almost stagnant Polar air that is believed to give rise to the succession of cyclones which we associate with the Polar Front. The formation of cyclones on this hypothesis is best understood by reference to the diagram. It will be seen that a whirling motion of the air is set up in which the winds blow round a centre, actually a low pressure centre, in a counter-clockwise direction. Where the warm moisture-laden air meets the cold Polar Front condensation takes place, especially when the warm air is forced over the cold air. The indraught of cold air from the north which marks the passing of the cyclone is accompanied by a drop in temperature, but, after an initial cloudiness explained in Fig. 51, by a clearing of the sky. If one accepts this explanation of the formation of depressions, the fact that the Polar Front is approximately over Iceland would result in a continuous succession of depressions passing across Iceland in a north-easterly direction. If one takes an average of such conditions one gets the conception of a semi-permanent low pressure system situated approximately off Iceland.

Weather and Climate of North-West Europe

Before considering the weather conditions in the British Isles in particular, it will be necessary to look at the weather conditions affecting the whole of Europe, and it is simplest to do this by contrasting the winter and the summer conditions.

Winter conditions.—In the winter months the Continent of Europe lies in the belt of the westerly winds, warm moisture-laden winds from the Atlantic Ocean. The extra-tropical belt of high pressure at this season lies well to the south of the Continent—over the Sahara and its continuation into the Atlantic Ocean to the south of the Azores. Thus there is a high pressure area over the Azores and, as we have already seen, a semi-permanent low pressure system roughly over Iceland. But the eastern part of the Continent is very near the great land mass of central Asia, of which it is indeed a continuation, and so at this season gets extremely cold. One may picture a great mass of cold heavy air over Asia and eastern Europe, giving rise to a permanent high pressure system in the winter. The warm moisture-laden air from the Atlantic blows up against this, as against a wall, and either finds a way of escape to the north-east along the coast of Norway, or a way of escape to the south along the Mediterranean. At times this great high pressure system of eastern Europe, with its cold outblowing winds, may exert its in-

fluence even as far as the eastern shores of the British Isles and may therefore give rise to cold and frosty, though often sunny, weather. Indeed it may be said that the winter weather of the British Isles is determined by the relative strength or importance of these three great pressure systems—the semi-permanent low pressure system over Iceland, the permanent high pressure system over eastern Europe, and the high pressure system south of the Azores. Bearing these facts in mind it is not difficult to understand why in the winter months it becomes steadily colder as one travels eastwards across the British Isles and, indeed, as one travels eastwards in Europe.

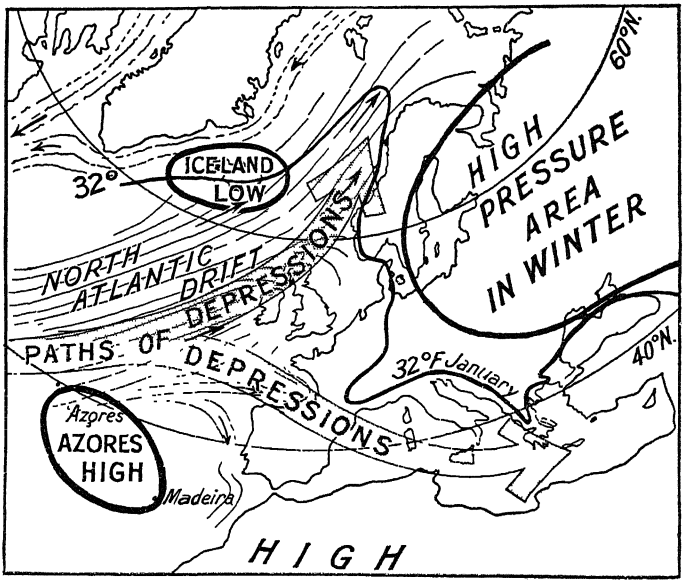


FIG. 47.—Generalised winter conditions

Many of the depressions moving along the southern path do not, in fact, penetrate farther than Italy

In Europe we find that the isotherm of 32°, or freezing point, divides the Continent roughly into two halves and, as we have already noted above, we may look upon this isotherm as marking approximately the position at this season of the Polar Front. Thus the cold mass of air over Russia and eastern Europe may be regarded as lying within the Polar Front. At this season the moisture-laden winds from the west deposit their moisture on the western sides of the land masses; they are unable to penetrate very far towards the east and so there is comparatively little precipitation in the east. This is apparent even in the British Isles, where in the western half of the islands more than half of the total rainfall comes in the winter

months, whereas in the eastern half of the islands the greater rainfall is during the summer months (see Fig. 61).

Summer conditions.—At this season the wind systems of the world have moved to the north of their average position, so that only the northern part of Europe comes under the influence of the westerly winds. The southern parts of Europe, that is to say the countries surrounding the Mediterranean Sea, lie within the influence of the high pressure belt which almost girdles the globe just outside the Tropics. The high pressure reigning in the summer months over the Mediterranean prevents the penetration of the cooling,

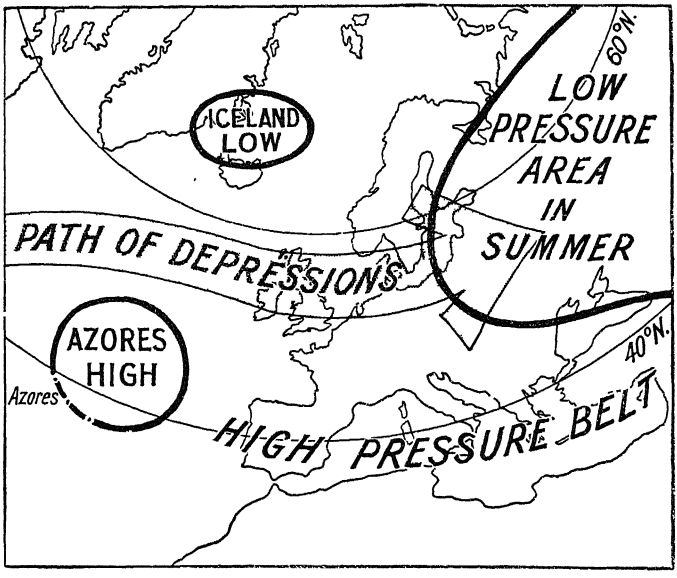


FIG. 48.—Generalised summer conditions
The main depression path might more justifiably be shown north of the British Isles

or rain-bearing, winds from the Atlantic Ocean. Consequently the Mediterranean Lands suffer from considerable heat and comparative, or even complete, rainlessness. In the Atlantic the high pressure centre of the Azores, which forms part of this belt of high pressure, is north of its winter position and frequently extends its influence as far as the British Isles. On the other hand the Polar Front is farther to the north and the belt of cyclones which is associated with it tends to be rather north of the island of Iceland and to affect the British Isles far less than in the winter. In eastern Europe the conditions of winter are reversed. The great Continental land mass is greatly heated and a large low pressure area is the result. There is a tendency for the low pressure to be par-

ticularly marked over southern Russia, and towards this area the rain-bearing winds from the Atlantic blow and result in the light spring rains of the steppelands of south-eastern Europe. Thus central and eastern Europe have the greater part of their rain, that is to say more than half the annual total, in the summer half of the year rather than in the winter.

It needs but a glance at a map of Europe to realise that the British Isles tend to be centrally situated between the three main pressure systems, and actually our weather, both in winter and summer, is largely determined by their relative strength. In winter there is a distinct tendency for the low pressure system over Iceland to be the most potent in determining the weather of these islands, except in those years when the high pressure system over eastern Europe is exceptionally strong and extends its influence as far as the east coasts of Scotland and England. For example, in the winter of 1928–1929, and again in 1939–1940 and 1946–1947, when settled cold weather prevailed for long periods at a time, with cold easterly or north-easterly winds, it was found that the pressure system of eastern Europe was extending its influence as far as these islands. It should be noticed that when one of the high pressure systems extends its influence in this way there is a distinct tendency for the weather to remain settled for considerable periods of time. Thus in summer, when the high pressure system of the Azores stretches rather north of its normal position, there is a possibility that at least the south of England will enjoy long spells of fine weather. This happened in the summer of 1921,[1] again in 1929, in 1931 and in the summer of 1947. These summers were marked, during the months of August and September, by fine and hot weather over the whole of the southern three-quarters of the islands; but in 1929 in particular the summer was marked in northern Scotland by an extended period of bad weather: in other words, the path of the cyclones from the Atlantic lay along the northern fringe of the high pressure system which remained comparatively stable over southern Britain. More rarely the Azores High may extend its influence over much of Britain even in winter. This was the cause of the late winter drought and exceptionally warm weather of early 1953.

So far we have considered only the three great pressure systems which are dominant factors in determining European weather, but actually the weather in these islands is determined to an even greater extent by the passage of a succession of secondary depressions, or secondary cyclones, with intervening ridges of high pressure. Since the British Isles are intermediately placed between the three great pressure systems of Europe both in summer and in winter, it follows that the line of passage of these secondary depressions

[1] *Quart. Jour. Roy. Met. Soc.*, XLVIII, 1922, 139–168 (dealing with droughts in general).

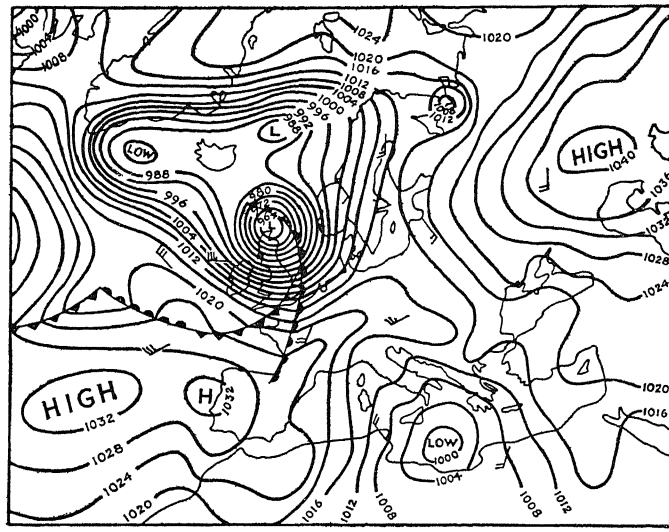


FIG. 49.—Weather conditions on Sunday, December 30th, 1951

This weather chart shows typical winter conditions with a high pressure system over eastern Europe; a "high" over or near the Azores, and a low pressure area, with several centres, between Scotland, Iceland, and Greenland Such a situation, with warm and cold or occluded fronts, passing across the British Isles, gives the characteristically variable weather of the British winter. A characteristic small depression is passing over the Mediterranean. Isobars are shown with values expressed in millibars.

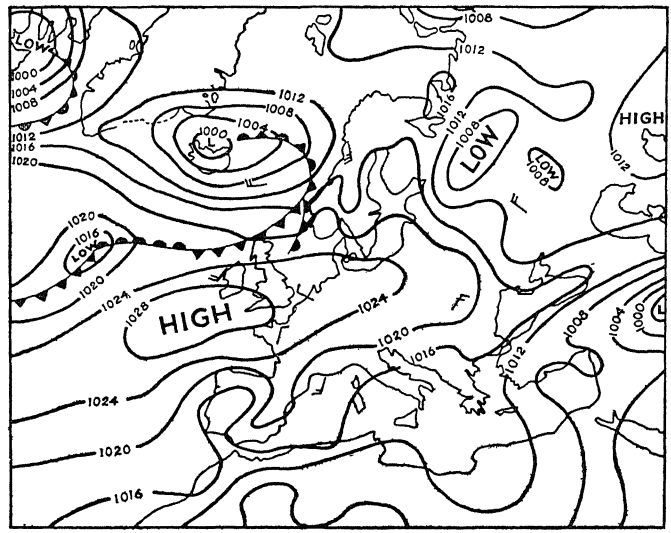


FIG. 50.—Weather conditions on Sunday, July 1st, 1951

This weather chart shows typical summer conditions, with low pressure systems over Iceland and eastern Europe and a "high" extending from the Azores to Britain. The "polar front" lies for the most part to the north of the British Isles, which are bathed in mT air. But in many summers the fronts frequently pass farther south so that rain and incursions of mP air are common.

must lie across these islands in both seasons of the year. Since this is the case it is desirable to examine in a little more detail the succession of weather which results. One must remember that a cyclone or depression in the Northern Hemisphere is marked by a low pressure centre with upward currents of air. Winds tend to blow round this centre, for reasons which have already been explained, in an anti-clockwise direction, and at the same time towards the centre, where they rise. When a depression, therefore, is approaching these islands from the Atlantic the barometer will fall and winds will be southerly to south-westerly, veering westerly later. Coming from the Atlantic, they will be warm and moisture-laden, blowing northwards towards cooler regions and also towards

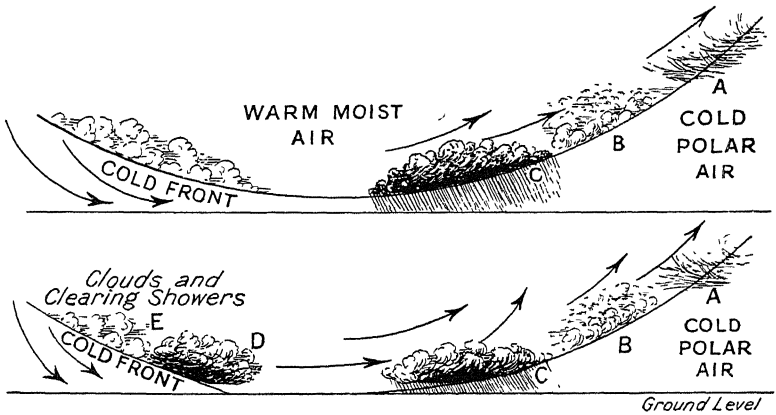


FIG. 51.—Sections through a typical depression

A, cirrus clouds indicating the approach of the depression. B, cumulus clouds followed by C, nimbus clouds with heavy rain. The "eye" of the storm is succeeded by cumulo-nimbus clouds (D) and cumulus clouds E, accompanied by clearing showers

the central depression where they will rise, rain begins to fall. Where the oncoming warm south-westerly winds meet the colder air, the "warm front," as it is called, is formed and along this warm front, where the air is cooled by rising over the cold air, rain is likely to occur, and prolonged steady rain may result. Subsequently there is usually a break in the weather. After the centre of the depression has passed across the islands, usually in a normally easterly, or north-easterly, direction, the barometer will again rise and the normal air currents will now be the colder winds from the north or north-west. These winds are comparatively dry, but where they impinge on the flanks of the south-westerly current intense rain with squalls may result. This is shown in the diagram. Actually the diagram illustrates a cyclone probably along the Polar Front itself, but the passage of a smaller secondary depression across the islands would produce comparable weather conditions.

The passage of such a small depression is often, one might say usually, followed by the passage of a ridge of high pressure, ushered in by the continuation of the cold northerly winds and a steadily rising barometer. Fine sunny weather may result in the summer, but as the winds decrease and calm conditions prevail the passage of such a ridge of high pressure is often marred in winter by the occurrence of fogs.

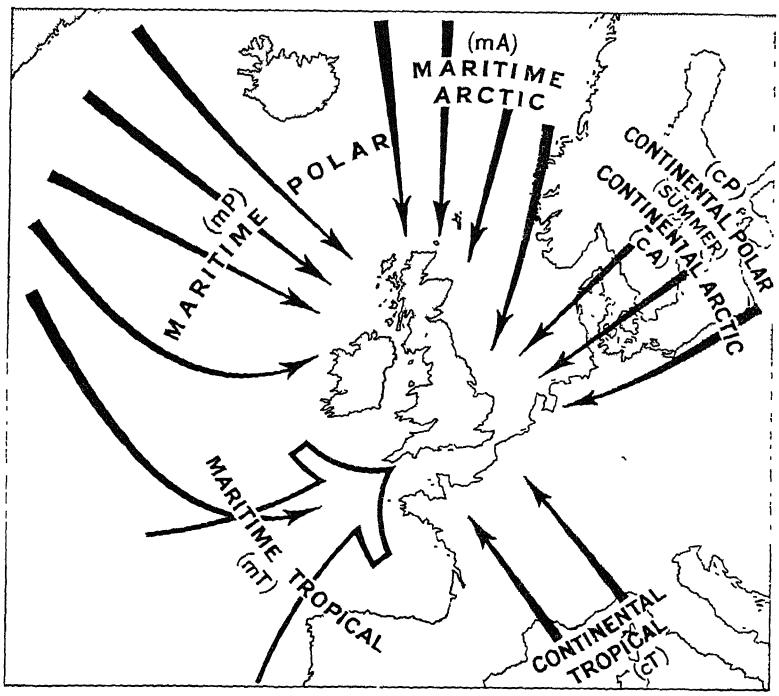


FIG. 52.—Diagram showing origin of air masses reaching Britain

Compare with Figs 47 and 48

The large generalised arrow for mT air is not intended to indicate that this is more important than mP air

Air Masses reaching the British Isles

It is now possible to re-state what has been said in the last few pages in modern terms by stating that the British Isles are affected by six principal types of air or air masses. Most of the air reaching Britain can be traced to one of three main source-regions—regions where the air has had sufficient time, such as a number of days, to acquire a degree of homogeneity of temperature and humidity throughout its mass. These three source regions are the Arctic, eastern Europe or Eurasia and the Atlantic high pressure area of the Azores—precisely the areas already clearly indicated on

Fig. 47. The Arctic yields maritime Polar air (mP) which may be intensified as a bitterly cold northerly air stream in winter when it is designated maritime Arctic (mA). Northern Russia and Siberia give us our most severe winter weather through the mass of continental Arctic air (cA) contrasted with the rather rare continental Polar (cP) and continental Arctic (cA) of Summer where air masses from the same quarter have been warmed in their passage eastwards. The rarity of such air masses reaching Britain is clear from Figs. 49 and 50 which show the normal movement away from Britain. The Atlantic area over the Azores yields maritime Tropical (mT) air; much rarer (almost unknown in winter) is continental Tropical (cT) from North Africa or the summer Mediterranean.

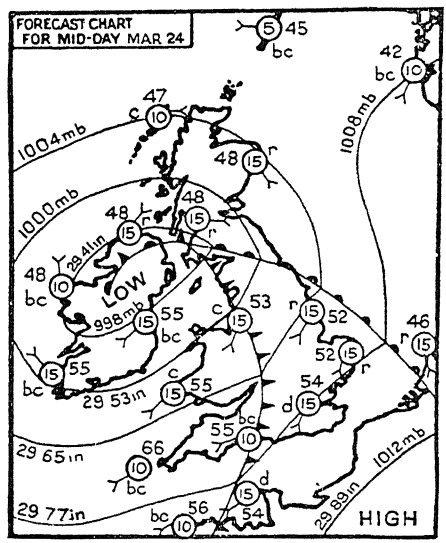


FIG. 53.—Weather map showing a typical depression, with warm and cold fronts, crossing the British Isles

(Reproduced by *The Times*, London, by permission of the proprietors)

The Equinoxes

In the analysis of the general conditions in Europe we referred to the formation of a great high pressure centre over eastern Europe in winter and the formation of a low pressure centre over the same area in summer. Naturally there must be two seasons of the year when the change from one to the other takes place, and it is very largely the resulting disturbance of atmospheric conditions which is responsible for the well known equinoctial gales experienced in this country. Whilst in the early part of the year high winds are associated with the month of March and the fame of March winds is perpetuated in many a nursery rhyme and popular ballad, the change indicated by these winds does not always take place at exactly the same time. In some years March may "come in like the lion and go out like the lamb," in others it may come in like the lamb when the winter conditions still prevail, but go out like the lion. The corresponding high winds associated with the disturbances at the autumnal equinox are the equinoctial gales of September and October. After the equinoctial gales of March come the still

unsettled conditions of April, when numerous small secondary disturbances result in April showers. The small rainfall of the early spring months can be correlated with the small evaporation. Indeed, evaporation is almost confined to the six months April to September. There is a definite lag between the increase of evaporation in April and the increase in the mean rainfall per rain-day which does not exceed the average for the year until July. Similarly the mean rainfall per rain-day continues above the average for the year for some three months after the evaporation has practically ceased at the end of September.

Temperatures

So far we have been dealing with the weather conditions of the British Isles, and owing to the irregular succession of weather it is

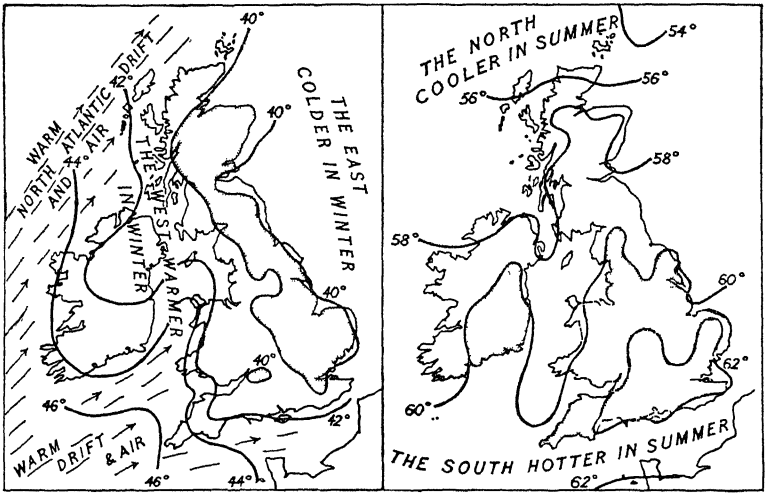


FIG. 54.—Temperature conditions in January (1906–1935)
Isotherms in degrees Fahrenheit

FIG. 55.—Temperature conditions in July (1906–1935)
Isotherms in degrees Fahrenheit

Mean temperatures reduced to sea level (after E. G. Bilham)

sometimes said that the British Isles have no climate, since climate is described as the average state of the weather. This may at least serve as a useful reminder that we should use the averages mentioned in the paragraph below with care owing to the variability from year to year, and even during one year. Taking, first, temperature conditions in the winter, it may be said that in general conditions in the British Isles reflect in detail those prevailing in Europe as a whole. In winter the west is warmer than the east and the isotherm of 40 degrees in January roughly divides the islands into two and its curve should be carefully noted. As one

would expect at this season, the extreme south-west of Britain and south-western Ireland are, taking the average conditions in January, the warmest parts of the islands. The Scilly Isles have an average temperature in January of no less than 45 degrees, whilst snow and frost are both rare. The important effects which this has on the products which are possible in these areas, and on the use of warmer parts of Britain in winter as winter resorts, may be mentioned. Taking the evidence afforded by the isotherms alone the coldest parts in the British Isles in winter are certain tracts down the east coast, and it would seem that the east coast of Scotland in the neighbourhood of Aberdeen is not as cold as some parts of the coast of East Anglia farther south, but the ordinary dry-bulb thermometer is scarcely an adequate measure of temperature in so far as it affects human beings and there is perhaps a rawer quality in the air in northern tracts. In summer, by way of contrast, the south of the British Isles is warmer than the north. The isotherm of 60 degrees in July runs roughly from east to west. The south-east quarter is the warmest of all in July in the neighbourhood of London, but the average along the south coast is high. The coolest parts of the islands at this season of the year are the extreme north of Scotland, the Orkneys and the Shetlands. Though geographers have long been accustomed —perhaps too slavishly—to take January and July as the typical winter and summer months, they are not in the British Isles the coldest and warmest months respectively. It frequently happens in oceanic or insular climates that there is a considerable lag between the period when the sun's rays strike least obliquely or most obliquely on the surface of the ground and the time when the highest and lowest average temperatures are reached, so that for many parts

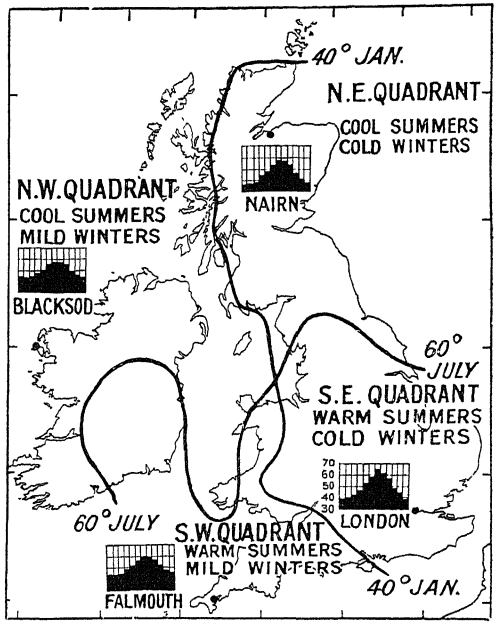


FIG. 56.—The four quadrants of the British Isles

of the British Isles February is the coldest month and usually August the hottest month. Even, however, taking January and July and noticing the course of the isotherms across the islands, it will be seen that the 40-degree isotherm for January and the 60-degree isotherm for July divide the islands roughly into four quarters. The north-west quadrant is the most "oceanic," and it is possible to find stations in the Outer Hebrides which have a range of only 56–43 (=13 degrees) between the winter months and the summer months. The south-east quadrant is the most nearly "continental," if that adjective can be applied at all to any part of the British Isles. Nevertheless, the temperature range of London is from 64 to 38 degrees—no less than 26 degrees—quite a remarkable contrast to the stations just mentioned.

So far we have been considering temperature as it affects lowlands, and the isotherms which have been discussed are sea level isotherms. If one considers the actual surface temperatures as recorded the theoretical difference between actual temperature and temperature reduced to sea level is 1° F. for every 300 feet. Since the greater part of Lowland Britain is less than 600 feet above sea level the theoretical difference does not exceed 2° F. Elevation begins to exert an important effect on the higher ground of Highland Britain and on the top of the highest point in the British Isles, Ben Nevis, at 4,400 feet, the temperature if reduced to sea level equivalent would be nearly 15° F. higher.

The effect of elevation justifies us in regarding the Highlands of Scotland in January as the coldest part of the country. The factor of elevation is readily apparent when snowfall is considered (see Fig. 62). Whilst in the south-west of the country, in Devon and Cornwall, snow does not normally fall on more than five days in each year, and is not found to be lying for more than five days, such lofty tracts as Dartmoor are frequently seen to have a powdering of snow. Indeed, on the higher parts of Dartmoor snow normally lies for more than twenty days in every year.

The effect of elevation on temperature is however far from simple. Cold air behaves much like cold water. It flows downhill and will collect in a valley or basin where there is no outlet and gives rise to a "frost pocket" or "frost hollows." Some extremely low temperatures have been recorded in such obstructed valley situations amongst the Chiltern Hills. On the other hand, where cold air can drain freely as it does down river valleys and out over the sea, such frost pockets are absent.

Studies which have been undertaken in connection with the growing of fruit and the siting of fruit orchards have shown how very important it is to secure free drainage of air. Even a high hedge can hold up air movement and increase the hazards of frost. In addition aspect plays a much greater part in the determination

of local climates than has been suspected in the past. If one attempts to determine the upper limit of cultivation in such areas as the Pennines, one finds that cultivation is almost invariably to a higher level on the northern sides of valleys, that is to say on those slopes facing southwards towards the sun, than it is on the southern sides of the valleys. Dr. Alice Garnett[1] has carried out elaborate studies showing how important this fact is in the Pennine valleys of West Yorkshire.

Hills running from east to west afford a remarkable protection from cold northerly or north-easterly winds. The attraction of

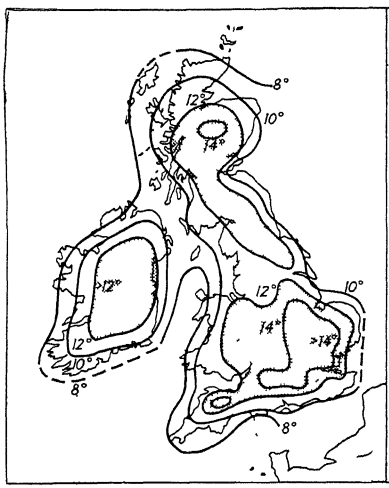


FIG. 57.—Mean daily range of temperature (whole year): (1906–1935)

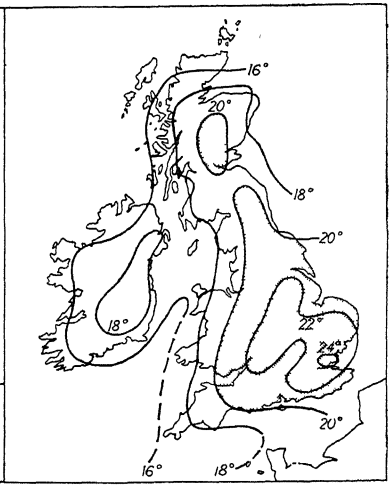


FIG. 58.—Mean annual range of temperature (1921–1935)

Both these maps are after E G Bilham and clearly illustrate the moderating influence of the sea in lowering the range of temperature both diurnal and annual, whilst Fig. 58 illustrates the relative continentality of south-eastern England

Ventnor, on the southern side of the Ise of Wight, is very largely due to the protection of the town from northerly winds by the high chalk downs which lie immediately behind. The early cultivation of tomatoes along a strip of the Sussex coast in the neighbourhood of Worthing is in large measure due to the protection afforded by the South Downs in the immediate hinterland. The delightful mildness of Aberystwyth, which is important to the town as a resort, is again partly due to the protection by the Welsh hills behind. By way of contrast some of these sheltered resorts are described as enervating by those who prefer the more bracing conditions from the vigorous winds of the east coast in the winter. This brings us to

[1] "Insolation and Relief," *Inst. Brit. Geographers*, Publ. No. 5, 1937, and later works.

a consideration of the very important question of frost. The following table shows the normal number of days when ground frost occurs at some widely scattered stations in Britain:

NORMAL NUMBER OF DAYS WITH GROUND FROST

Station	Height	J	F	M	A	M	J	J	A	S	O	N	D	Total for Year	Days with snow
Balmoral	930	23	21	21	17	9	3	2	1	5	10	18	21	151	50
Glasgow	180	12	10	11	8	3	1	0	0	4	8	10	12	79	16
Birmingham	535	17	15	15	11	5	1	0	1	3	7	14	13	102	11
London	18	15	15	15	13	4	1	0	0	2	8	14	14	101	13
Clacton	54	12	13	11	7	1	0	0	0	0	1	7	9	61	16
Liverpool	188	14	14	18	9	1	0	0	0	0	1	10	13	80	11
Falmouth	167	8	8	10	5	0	0	0	0	0	1	6	9	47	5
Guernsey	295	6	6	5	3	0	0	0	0	0	0	3	4	27	—

A distinction is made between days on which snow is seen to fall (given in this table) and days with snow lying (Fig. 62).

The danger in such enterprises as fruit farming is particularly one from late frosts in spring which may occur after blossoming and which damage the young fruit before it has had time to grow large enough to resist damage. There are many plants which are killed by the first frost of the autumn, e.g. soft stemmed plants like the vegetable marrow, or flowers such as nasturtium. It is the shortness of the growing season between the last killing frost of spring and the first of autumn, as well as the absence of really high summer temperatures which prohibit the cultivation in the British Isles on a farm scale of such a crop as maize.

Another crucial temperature is 42° or 43° F. At temperatures below this figure most plants are dormant and vegetative growth only takes place when temperatures rise above this figure. This factor is important where fodder grasses are concerned. Since the average temperatures for the coldest month are above this crucial figure in the south-west of England some vegetative growth is going on even in the coldest month, and stock left out in the open can find at least some sustenance in new growth which may be rare or completely absent in colder eastern regions.

Most of the preceding references have been to average temperatures. Considerable importance must be attached to temperature ranges both daily and annual. The two figures (Fig. 57 and Fig. 58) show how the mean daily range throughout the year increases steadily inland from the coasts. This is in some contrast to the mean annual range of temperature which is actually greatest near the south-east coast, and least over the windy islands of north-west Scotland.

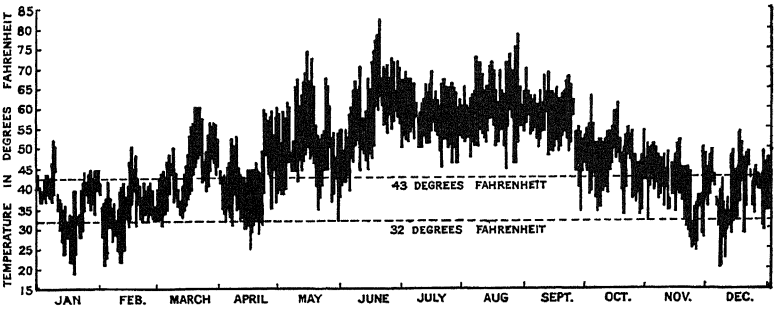
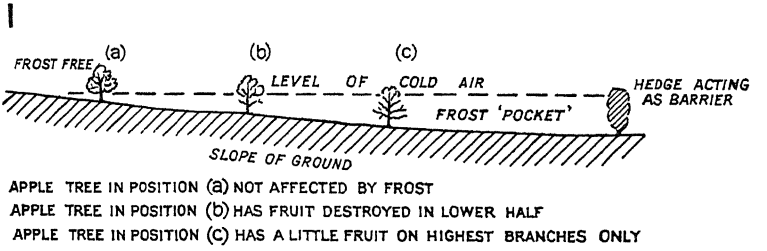
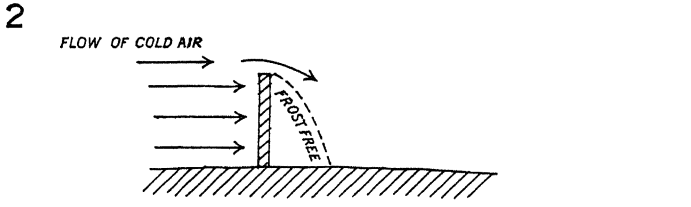


FIG. 59.—Diagram showing the temperature range for each day in a typical year (1936) at Macclesfield, Cheshire, 500 feet above sea level

Notice the number of days when the temperature exceeded 43° F., the crucial temperature for plant growth. By adding together the number of degrees shown in this diagram above 43° F. one gets the concept of accumulated temperatures expressed in day degrees





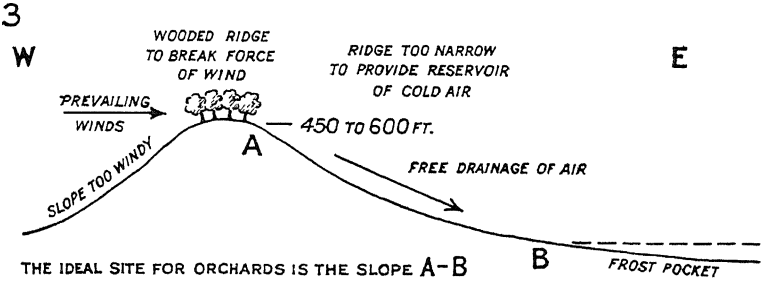


FIG. 60.—Diagrams showing the relationship of air drainage to frost pockets and frost-free slopes

Considerable importance must also be attached to absolute maxima and absolute minima, especially the latter. A maximum temperature during the day exceeding 90° F. in the shade is not infrequently recorded at many stations. Records of 100° F. and over are extremely rare but have been recorded. For long it was doubted whether a temperature as low as 0° F. had ever been recorded. Any doubt, however, regarding the possible occurrence of such low temperatures in the British Isles was removed once and for all during the long cold spells of the winters of 1939–1940 and 1946–1947 when quite definitely temperatures down to −4° F. were officially recorded. Though very rare such very low temperatures were found to have an unexpected importance. Many plants normally hardy failed to survive and a good example was the widespread destruction of the Californian *Cupressus macrocarpa*. Trees of this species which had flourished for ten to fifteen years were killed by the very low temperatures, probably because the low temperatures were maintained for several days.

Precipitation

In the British Isles precipitation includes drizzle, rain, sleet or hail, and snow, which fall on to the surface of the ground, whilst moisture may also be precipitated from the air as dew and hoar frost or rime, which are directly deposited on exposed surfaces. The distinction between drizzle and rain is now commonly made on the basis that a drizzle drop, from one-eightieth to one-hundredth of an inch in diameter, is only one-quarter to one-twentieth of the size of a raindrop. Whereas raindrops usually fall, drizzle is drifted by the wind.

The measurement of moisture deposit as dew or hoar frost is difficult and its influence on vegetation is imperfectly understood. The other forms of precipitation are usually reduced to rainfall equivalent and the remarks which follow regarding rainfall distribution must be taken as including also these other forms of precipitation. A map has been prepared showing the average annual rainfall of the British Isles, together with rainfall graphs showing the distribution of rainfall in the different months of the year. These indicate certain important points: the first is the well distributed rainfall throughout the year, characteristic of the British Isles; the second is the general tendency for stations on the west to receive the greater part of their precipitation in the winter, while farther east the greater proportion of the rainfall occurs in the summer half of the year. The third is that in general there is an autumn maximum, usually reached in October, extending roughly for the period of the equinoctial gales.

Then the map illustrates quite clearly the general broad distinction between the drier east and the wetter west, with the areas of heaviest

rainfall—more than 60 inches—on the upland and highland areas, particularly of Scotland, the Lake District, the Pennines, Wales and western Ireland. The average annual rainfall is about 20 inches in the neighbourhood of the Thames estuary and probably reaches

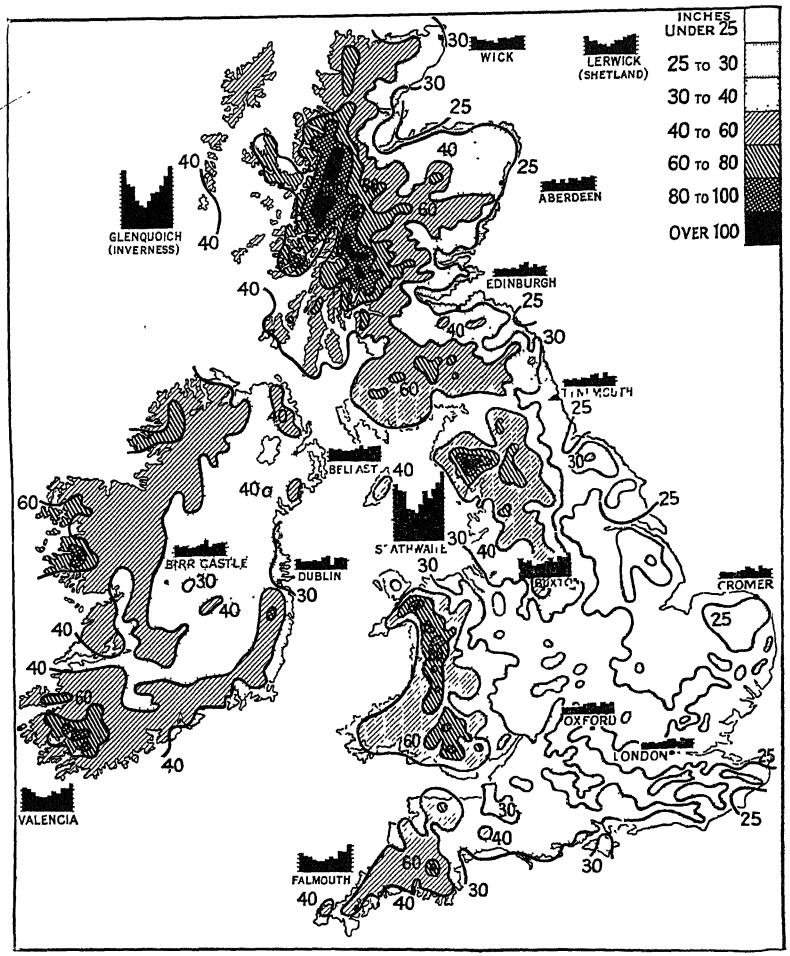


FIG. 61.—An Annual Rainfall Map of the British Isles

With the steady accumulation of data, refinements and changes in such a map are possible. For a detailed modern map of Great Britain that in the National Planning Series on the Scale of 1:625,000 (in two sheets, Ordnance Survey) should be used

200 inches over small areas in the Western Highlands, at the head of the river Garry and on Snowdon. This suggests at once that the rainfall of the British Isles is mainly orographical, but if it were entirely orographical, then the east, of course, would be much drier than is actually the case. In reality the rainfall of the British Isles

is partly orographical—due to the relief of the islands—partly cyclonic and, in a smaller degree, brought by thunderstorms.[1] It is now generally agreed that the main effect of relief is to bring down more rain from the passing depressions.

It may be said at once that the rainfall in all parts of the British

FIG. 62.—Snowfall in the British Isles, showing the number of mornings with snow lying, annual average 1912–1938 (after Gordon Manley)

[1] The effect of "continentality" is apparent, for the annual totals of rainfall when expressed as percentages of the average annual rainfall are more than twice as variable in central districts of England than along the extreme north-west of Ireland. See C. S. Salter, *The Rainfall of the British Isles*.

An investigation by Professor S. H. Beaver of the rainfall at Keele, Staffordshire, in 1952, showed the percentages of the total precipitation due to different causes to be as follows: Warm Front, 20·9; Warm Sector, 16·6; Cold Front, 16·0; Occlusion, 17·5; Instability in mP air mass, 21·8; Arctic and Polar Continental Air Stream, 3·2; Thunderstorm, 3·0, Undetermined, 1·0. Of these "warm sector" rain is largely orographic in character, whilst frontal rain is always liable to be accentuated by relief and elevation.

islands is adequate for agricultural purposes and, in many of the more hilly regions, the rainfall must actually be classed from this point of view as excessive. The coasts of Ireland, western Scotland, and many parts of western England and Wales receive too much moisture to make farming possible or at least profitable. A severe limitation is applied by excessive moisture on crops which can be grown by the arable farmer, and it is not too much to say that farming of all types may be prevented in certain areas. Further consideration will be given to this question later, but it may be said that cereal farming, with the exception of the cultivation of that hardy crop —oats, is largely restricted to the regions having less than 30 inches of rain per year. It has, indeed, been suggested that England can be divided into four agricultural provinces by using the 60-degree July isotherm and the 30-inch rainfall line, since the 60-degree isotherm marks the approximate northern *economic* limit of the cultivation of certain crops (*e.g.* wheat).

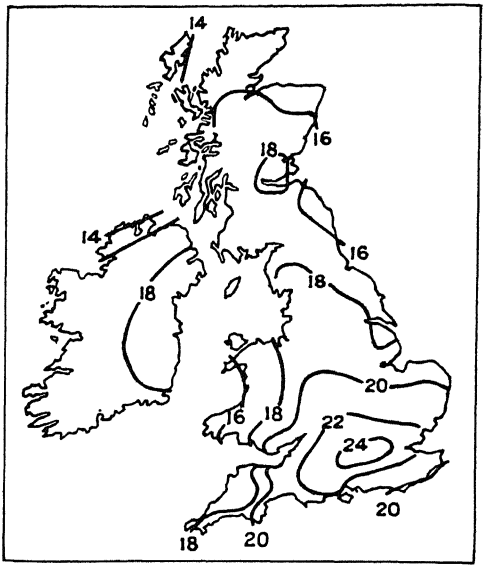


FIG. 63.—Evaporation from open water in the British Isles. Average annual amount in inches (after J. Wadsworth)

Rainfall by itself is not, of course, an adequate measure of the relative wetness or dryness of a country from the agricultural point of view, but with cloudy skies and comparatively low temperatures throughout the year evaporation is relatively small[1]; long periods of drought are unknown. Further, the variability of British rainfall from one year to another is comparatively slight; it is rare for any part to experience more than 160 per cent or less than 50 per cent. of the average. There are occasions when the British farmer, robbed of showers of rain at just the seasons when he considers his crops require moisture, complains of drought; but the British Isles may be said never to suffer from drought in the way

[1] Evaporation from exposed water surfaces has recently been shown by J. Wadsworth to vary more than was previously believed—from under 14 inches per annum in north-west Ireland and north-west Scotland to over 24 inches in the heart of the London Basin.

in which that scourge may affect such an area as Australia. The difference in moisture conditions between the western and eastern sides of Britain is perhaps greater than would appear from merely an examination of rainfall figures. Since the largest proportion of the rain on the eastern side is cyclonic in character, periods of heavy rain tend to be separated by days when rainfall is practically

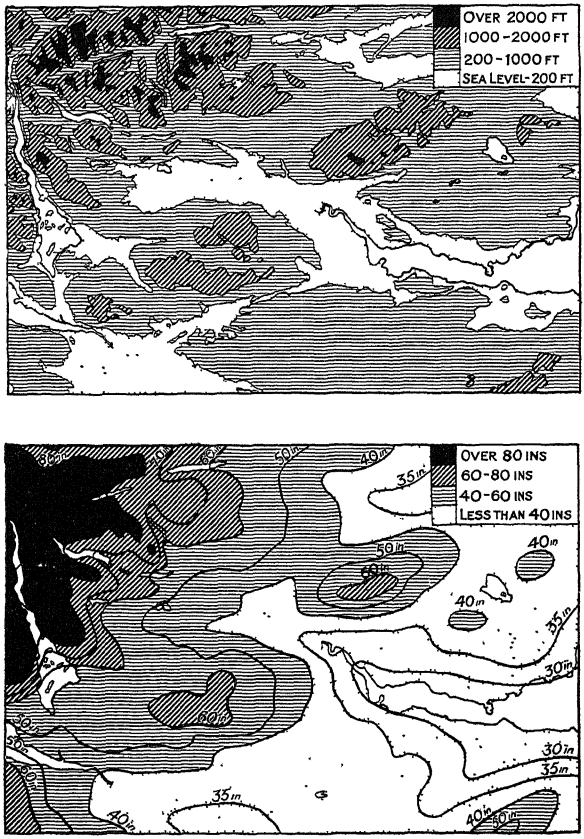


FIG. 64.—The correlation between relief and rainfall in the Midland Valley of Scotland (after H. R. Mill)

nil. On the other hand, in the west, particularly in Ireland, there is a much greater tendency for a succession of days of light drizzle. It is a common greeting in Ireland for one farmer to say to another, "Fine soft day to-day," meaning a day characterised by warm gentle drizzle. The average number of days with rain increases very steadily from the south-east to the north-west of the British

Isles. This is due to the greater frequency of depressions to the north of these islands. Unlike the actual quantity of rainfall, geographical position is of more importance than altitude in determining the number of days with rain.

Sunshine and Cloud

Some measure of this difference is afforded by the accompanying sunshine maps of the British Isles. Fig. 65 illustrates the advantages of situation along the south coast and along the east coast.

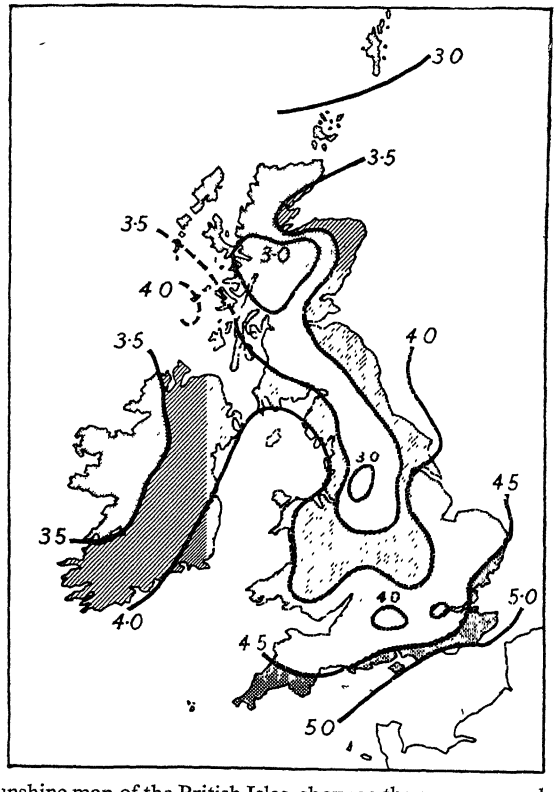


FIG. 65.—Sunshine map of the British Isles, showing the average number of hours of sunshine per day throughout the year (1906–1935). (After E. G. Bilham)

and in lowland areas some distance from mountains which attract cloud. There is a general tendency, too, for a larger proportion of winter sunshine in the south, one reason being because of the longer winter days. It must not be forgotten that the northernmost part of Britain is sufficiently near the Arctic Circle for the summer nights to pass without complete darkness being reached, at least that is the case in the Shetland Islands in the latter part of June

and July, when it is said to be possible to read by the twilight. It is of some interest to note the way in which resort towns have seized upon salient facts of British climate for advertisement purposes. Common slogans include, "South for Sunshine," whilst Skegness on the "drier side" of Britain is "so bracing." It may, however, be mentioned that the west coast scores in that slightly more rain falls at night than during the day, while along the east coast slightly more rain falls during the day than at night, the east coast districts experiencing thunderstorms during the late afternoon rather more frequently. The fame of the mild winters of the Mediterranean coast of France, or the French Riviera, was

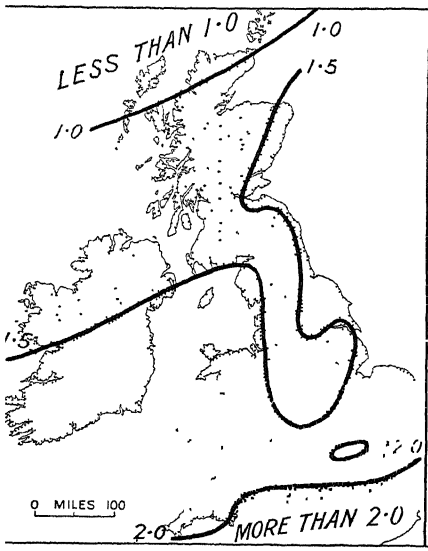


FIG. 66.—January sunshine, expressed in number of hours per day

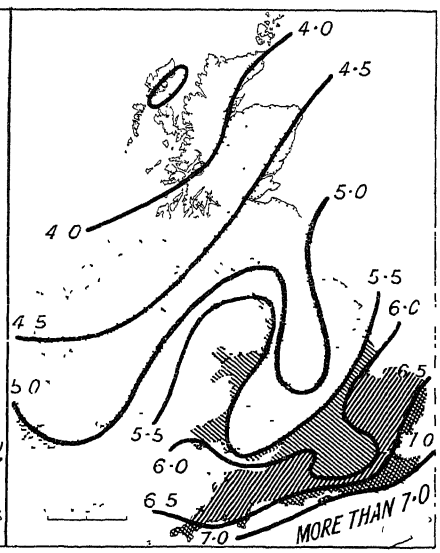


FIG. 67.—August sunshine—the number of hours per day in the chief "holiday month"

doubtless responsible for the application of the name "Cornish Riviera" to the coast of Cornwall. Everyone knows the Cornish Riviera express of the old Great Western Railway; a few years ago a widely used poster on that railway showed the Cornish peninsula on one side pointing to the south-west and the Italian peninsula on the other side pointing to the south-east, intending to suggest, of course, the similarity between the two. It is interesting to note that if one takes just the temperature records of coastal towns there is little difference between those of Cornwall and those of the French Riviera. For example, the mean January temperature of Penzance is 44 degrees, the January temperature of Nice is 46 degrees. The main difference comes in the sunshine records of 25 per cent. of

the possible for the months of December, January, and February for Penzance and over 50 per cent. for the same months for Nice. Even so the figures are sufficient to explain the reason why one should find such warmth-loving plants as the palm and the *Yucca* growing outdoors in the sheltered Cornish resorts and why they should justify their existence as winter resorts for invalids. Torquay, more accessible and developed with the amenities of a winter resort, has a January temperature of 42·3 degrees and a sunshine record for that month of 2 hours per day.

Wind and Fog

The dominant direction of the wind in the British Isles is from the south-west, though wind roses in different situations show that the degree of dominance varies widely. Exposed situations on the western coastlands illustrate very well by the deformed growth of trees how important wind can be.

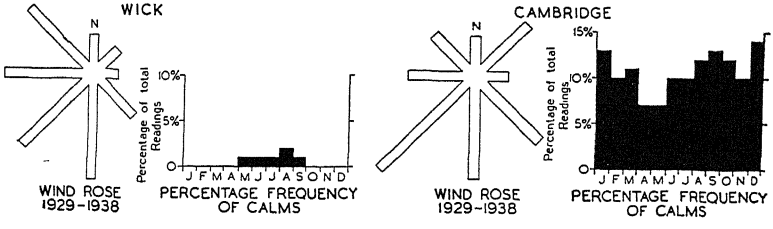


FIG. 68.—Wind conditions in Wick, Caithness, and Cambridge, 1929–1938

At Stornoway in the Outer Hebrides the average number of "days with gale" reached 48 in every year; the Scilly Isles record 25. This may be contrasted with Tynemouth on the east coast with only four, and Kew, London, where normally none is recorded. A gale is defined officially as "wind exceeding 39 miles per hour."

At least abroad, the British Isles have a reputation for fog, in very large measure undeserved. The old "pea-soup" fogs of London and other great towns were, of course, connected with the excessive use of imperfectly combusted coal and the humidity of the atmosphere: furthermore, the additional heat resulting from the increasing number of houses, etc., has tended to disperse the fog at the level of the streets in recent years. Thus instead of dense fogs at ground level we have "high" fogs only. The days when Sherlock Holmes and his friend Dr. Watson contemplated the fire in a Baker Street flat while the impenetrable fog remained outside have doubtless gone for ever. An attempt has been made, in the table adjoining, to show the number of foggy days in parts of the British Isles. Settled anti-cyclonic conditions in the winter are the most dangerous period. Sea mists, driving up the Channel,

are most important, these being caused, of course, by the slight movements of damp, moist air reaching the colder air over Britain itself. Fog or sea mist of this sort is not infrequently responsible for delaying ocean vessels and was directly responsible for the discontinuance of a very useful way of crossing from Britain to the Continent—from Tilbury to Dunkirk (Dunkerque).

NUMBER OF DAYS PER YEAR ON WHICH FOG IS NORMALLY RECORDED (DATA FROM OFFICIAL PILOTS' MANUALS)

Falmouth	10	Yarmouth	43	Malin Head	16
Plymouth	30	Hull	30	Valentia	5
Portsmouth	11	Scarborough	46	Cork Harbour	18
Dungeness	38	Tynemouth	39	Donaghadee	6
Dover	17	Leith	14	Glasgow	9
Margate	11	Aberdeen	18	Liverpool	18
Shoeburyness	42	Wick	21	Pembroke	45
Greenwich	46	Stornoway	5		

London, Greenwich:—Jan. 7; Feb. 4; Mar. 3; Apr. 1·5; May 0·5; June 0·8; July 0·1; Aug. 0·7; Sept. 4; Oct. 7; Nov. 10; Dec. 7.

Calculating the average duration of the fog at 4 hours on each day recorded, nowhere at the stations shown would fog occur during more than 2 per cent. of the year, *i.e.* 98 per cent. of the year is fog-free at the worst stations and 99·7 per cent. at the best. Including sea mist, some stations, it should be noted, may be only 85 per cent. mist-free.

The term "fog" is used by international agreement whenever the visibility is less than one kilometre (about 1,100 yards).

Variations in British Climate

There is a widespread belief that the climate of the British Isles is changing, and people are fond of stating that we do not get as severe winters now as occurred in the days of our forefathers; and they point out that it is now no longer possible to roast an ox on the ice of the Thames frozen over. In this particular example, as in so many others, the full facts of the case are not taken into consideration. If the Thames of the present day were allowed to flow almost unrestricted through banks very wide apart, it would doubtless freeze over just as easily now as it did of old. Some authors have been at great pains to collect accurate information, and it would seem that the weather of the British Isles does tend to occur in cycles, and a correlation may perhaps be possible between these cycles of weather and the occurrence of sun-spots. Gordon Manley in his *Climate and the British Scene* reviews the evidence and the present state of knowledge at some length; it would seem that there may be both major and minor cycles of weather. At the same time it is, of course, important to remember that in the early days of man's habitation of Britain, the country was under the influence of the great Ice Age,

and there has, *on the whole*, been a steady change from that time to the present, with an increase in temperature and a decrease in humidity, though there is evidence for relatively wet or "pluvial" periods in Neolithic and Roman times interrupting the general change in an inter-glacial period, and evidence is rather lacking as to whether the climate as a whole is still getting milder or not. Climatic fluctuations since the disappearance of ice from Britain have played a major part in the development of the present flora and fauna and the following table is based on one in Tansley's *British Islands and Their Vegetation* (1939).

c. A.D. 500–1900	Recent	? Warmer and drier	
c. 800 B.C.–A.D. 500	Subatlantic	Cool and wet	Formation of *Sphagnum* peat. ? spread of beech. Iron Age.
c. 3000–800 B.C.	Subboreal	Drier	Increase of pine and yew, entry of beech. Neolithic and Bronze Ages.
c. 5500–3000 B.C.	Atlantic	Warm and wet	Oak forest dominant. Mesolithic Age.
c. 7500–5500 B.C.	Boreal	Warm and dry	Birch and then pine dominant.
c. 8500–7500 B.C.	Preboreal	Fluctuations	Birch and pine.
c. 18000–8500 B.C.	Subarctic	Cold and dry	*Dryas* vegetation. Palæolithic Age.

It is probable that these climatic fluctuations are intimately connected with the final separation of Britain from the continent, and the establishment of the present oceanic circulation. The climatic periods in Britain are not necessarily contemporary with those established on the continent. This is discussed by L. D. Stamp, *The Evolution of the North Sea Basin* (Copenhagen, *Soc. pour l'Expl. de la mer*, 1938).

Phenology

An important aspect of applied climatology is the relationship of climate and the growing season of plants. It is well known that the incidence of spring is earlier in the south-west than in other parts of the British Isles and it has been possible, by recording the dates of first observed flowering of a number of widely distributed plants, to construct maps showing the relative dates of the coming of spring over the whole country. These phenological studies have an obviously important bearing on agricultural practice. For some years maps of the type of Fig. 69 were prepared and published, but doubts have been cast on the validity of the method. If the normal flowering dates of the plants selected are separated by some weeks or even days, an average has little meaning.

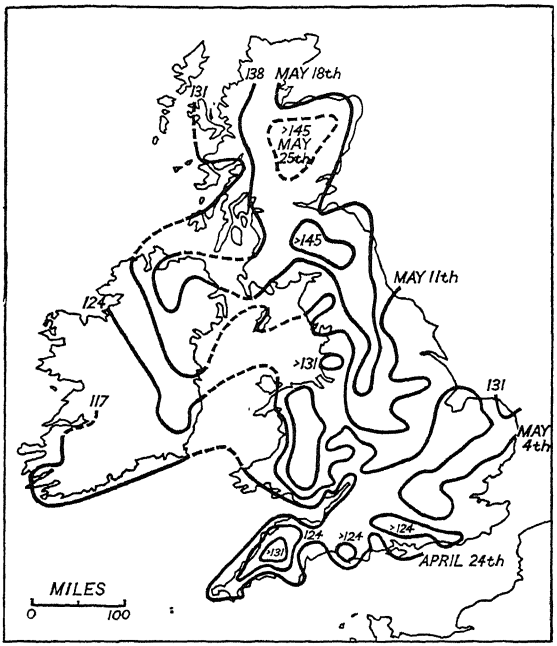


FIG. 69.—Phenological map of the British Isles showing the average dates of fourteen selected plants

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The Meteorological Office of the Air Ministry issues a *Daily Weather Report* (with charts both of the Northern Hemisphere and the British Isles in detail) which forms the basis of maps published daily in *The Times* and other papers. The Meteorological Office also publishes a *Monthly Weather Report.*

Founded in 1860 the British Rainfall Organisation was a voluntary organisation until the retirement of Dr. Hugh Robert Mill in 1919 and the carefully compiled annual volumes of *British Rainfall* are a mine of information. For modern advances in knowledge constant reference should be made to the *Quarterly Journal of the Royal Meteorological Society* and to the popular monthly *Weather* also published by the Society.

Sections on the climate of each county of Britain are published in the separate parts of *The Land of Britain* (London, 1936–1946) whilst a summary of the influence of climate on land use will be found in L. D. Stamp's, *The Land of Britain: Its Use and Misuse*, London, Longmans, 1949.

CHAPTER V

THE INLAND WATERS OF THE BRITISH ISLES

OF the rain that falls on the surface of the British Isles, part evaporates, part soaks into the ground, and part, usually a large part, runs off to form streams and rivulets, and eventually finds its way into the rivers of the country. That which percolates into the soil and into the rocks of the earth's crust is in part utilised by plants growing therein, and may eventually pass back into the atmosphere; but some of this water joins the underground water table and becomes part of an underground supply, being gradually returned to the open where the water table comes to the surface, and the water thereupon re-issues in the form of springs. Although recent work discussed in the last chapter has shown considerable variation in evaporation from one part of the county to another, over a large part of lowland Britain from exposed surfaces of water (*e.g.* lakes and reservoirs) it is equivalent to about 14 to 17 inches of rainfall. Thus in areas with a rainfall of 25 to 60 inches from 30 to 60 per cent. (over large areas between 40 to 50 per cent.) of the rainfall is lost by evaporation. This takes into consideration the greatly varying evaporation from land surfaces. It is not the purpose of this chapter to study the behaviour of underground water, or even of surface streams; but to regard the sum total of rain falling upon the surface of the British Isles as one of the natural resources of this country, and to study its utilisation.

The Evolution of British Rivers

The evolution of the existing British river system falls into three phases:

(*a*) the pre-glacial phase;
(*b*) the period of glacial interference;
(*c*) the period of man's interference.

It is certain that the main lines of the present relief of the British Isles were outlined before the coming of the great Ice Age. On the whole, many of the rivers must have followed substantially their present courses. In England and Wales, it is probably that the Highland Zone on the north and west of the country exercised a greater influence than it does at the present day, and that there were many rivers draining from the higher lands of Wales, or the north of England, following the general slope of the land towards

the south-east (see Fig. 13). The tectonic depression of the Thames Basin considerably ante-dates the glacial period, and it is likely that these south-easterly flowing rivers made their way into what may be called the proto-Thames.[1] The extreme south-east of England—the

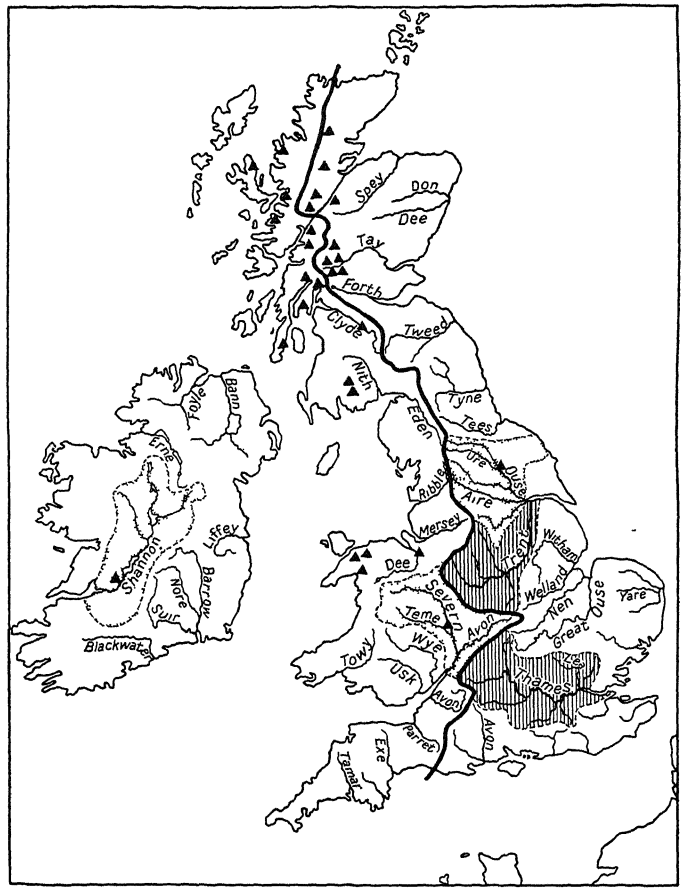


FIG. 70.—The chief rivers of the British Isles

The heavy line shows the main water parting; five of the larger basins are separately indicated
The black triangles are points where water power has been developed

Wealden area—is the classic area in the study of river development, mentioned above. The coming of the great Ice Age and the formation of huge ice sheets over the north of the country must have obliterated there the free surface drainage. As the ice spread south-

[1] For correction of this over-simplified statement see S. W. Wooldridge and D. L. Linton, "Structure, Surface and Drainage in South-east England." Publication No. 10, *Institute of British Geographers*, 1939.

wards so natural drainage channels were in many cases blocked and pent-up waters were compelled to find their way into new channels; in many cases they have never gone back to the old ones. The tongues from the ice sheets were responsible for the deepening of many of our valleys, especially in the Highland Zone. Thus many of the well-known lochs of Scotland are of glacial origin, so also are the famous lakes of our Lake District; whilst amongst the higher parts of the mountains of Wales the circular "cwm" or corrie lakes do much to add to the beauty of the scenery of that country. With the gradual departure of the ice sheet many pre-existing valleys were thickly covered, perhaps even obliterated, with glacial debris, effectively blocking old lines of drainage. In the lower parts of the country, especially where the glacial debris was clayey or impervious in character, there resulted the ill-defined drainage which to this day is characteristic, for example, of so much of the Central Plain of Ireland. Amongst the other marshy lands left behind were the Vale of York and the Fenlands of England.[1] The third stage in the evolution of the river system of the British Isles has been marked by the small, but cumulatively important, efforts of man to control drainage and more especially to drain some of the lower lying areas. How successful this has been can be judged by the complete conversion of the Fenland into what it is to-day—one of the best agricultural regions in the British Isles, and the almost equally complete drainage of the Vale of York. To a less extent man has controlled the drainage of the country for his own ends, for purposes of water supply.

The Utilisation of the Water Resources of the British Isles

It is remarkable, indeed well-nigh incredible, that there has been up to date no comprehensive study of the fresh water resources of Britain. Whilst almost from time immemorial such rivers as the Nile have been studied day in and day out, and their exact flow measured by gauges, no such records exist for British rivers. The seasonal rise and fall of rivers is a study of the utmost importance in many countries of the world. Their characteristic régime, as this rise and fall is called, may be a factor of national significance; but we do not know the régime of even the larger British rivers. Probably the Thames, because of its importance for the water supply of London, is the only river whose resources are comparatively accurately known. What is the reason for this neglect of the study of an important national resource? It is in the main a reflection of the climatic conditions of these islands. Broadly speaking,

[1] For an account of some outstanding examples of glacial interference with drainage, see L. J. Wills, *The Physiographic Evolution of Britain*, pp. 211–228. Many of the papers listed on p. 58 deal with the evolution of drainage.

in the past we have always had a superabundance of water for our requirements. The trouble has usually been too much water, and the difficulty of getting rid of the surplus. Thus the necessity of organising a survey of our national water resources has not, until comparatively recent times, become apparent. The Meteorological Office, as mentioned in the last chapter, is responsible for the collection of statistics of rainfall. The Geological Survey has concerned itself with underground water and since 1899 has published a series of water-supply memoirs on the counties. In these details of underground supplies from water bearing deposits or aquifers and existing wells are given. The importance of water in the war effort of the Second World War led to a systematic recording of information in which the Water Unit of the Geological Survey played an active part and notification of the results of well boring is now compulsory. What remains neglected is the surface water —the behaviour of rivers and the supply which is available from them for all purposes. In 1932 the British Association for the Advancement of Science appointed an Inland Water Survey Committee to study the means whereby such a survey could be undertaken. An Inland Water Survey Committee was set up by the Government in 1935 and a Surface Water Year Book published for 1935–1936 and 1936–1937. Both the Committee and the Year Book faded out during the War, to be resuscitated later. The Committee sponsored the publication of the Surface Water Year Book of Great Britain 1937–1945 (published by H.M.S.O., 1952) before the Committee was again suspended as an economy measure. It is clear that engineers of all important water supply and power undertakings must have an accurate knowledge of their resources and so carry out river gauging and flow measurements. The information available is collected in the Year Book. Some river basins (such as the Ness in Scotland, the Nene and Wye in England and Wales) are reasonably well covered: for much of the country there is still little information despite the anticipation by the Government of a national water policy.[1]

As the standard of living rises and all houses have running water and baths, 30 gallons or more per day must be allotted every individual. At the same time some modern industries, e.g. paper making and rayon manufacture, make enormous demands on water. The great urban centres seek their supplies in distant mountainous areas and the water is brought by aqueducts across rural land which may be very short of water. A modern dairy farm requires at least 30 gallons per cow per day, but few reach this standard unless they can have mains supply.

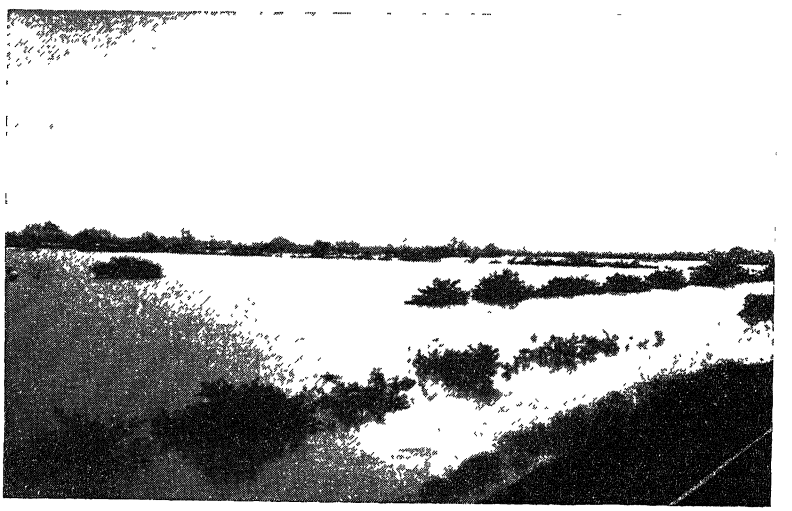
In the utilisation of our water resources it may be said that there

[1] A National Water Policy. Cmd. 6515, 1944, H.M.S.O.

are at least five frequently conflicting interests which regard the water resources of the islands from five different points of view:

(*a*) Land drainage
(*b*) Water supply
(*c*) Transport, i.e. navigation
(*d*) Water power
(*e*) Fisheries

Land Drainage.—In 1927 a Royal Commission, under the chairmanship of Lord Bledisloe, was appointed to inquire into the whole question of land drainage in England and Wales. In the evidence presented to that Royal Commission it was stated that there were $1\frac{3}{4}$ million acres of land in England and Wales alone in urgent need



[*Photo: L. D. Stamp*

FIG. 71.—Floods from the River Don, near Doncaster, illustrating the acute need for further drainage in parts of Britain

of drainage, and that 4,362,000 acres, about one-seventh of the land in agricultural use, depended absolutely on artificial drainage.

Land drainage is a complex matter. With the heavy rainfall over much of Highland Britain there is commonly an excess of water for agricultural purposes. Unless this is drained away soils become more and more acid and incapable of yielding good crops, grassland becomes waterlogged and the place of nutritious grasses is taken by reeds, rushes and mosses such as *Sphagnum* till the land becomes a useless bog. Two types of drainage are needed, one to drain off surface water, hence open ditches, the other to drain the soil, hence pipes a foot or so below the surface or channels cut underground by an implement which works like a mole (mole-drainage). It has

been estimated that in 1939, 9,000,000 acres or 40 per cent. of the farmland, excluding rough grazings, or a quarter of the total surface of England and Wales was in need of drainage of these types. Much work was carried out during the Second World War especially by prisoner of war labour but in 1952 the Drainage Division of the Ministry of Agriculture estimated that 3,500,000 acres were still in urgent need of drainage.[1] It will be seen that these greatly exceed the figures previously given to the Royal Commission.

The more effective the drainage of agricultural land, the greater the run off and the greater the danger of flooding from rivers overflowing their banks. There are still many parts of the British Isles which are subject to disastrous floods. To quote one example, in the valley of the lower Don, no less than 79 per cent. of the total area of 212,500 acres of the Doncaster area is below the 25-foot contour, and in urgent need of provision of adequate drainage.

The position is that the natural river channels are only sufficient to take off the surface water in times of normal flow and prove quite inadequate in times of excessive rainfall, which therefore results in widespread flooding. In the past, land drainage engineers have had to take a purely arbitrary figure in calculating the run-off from the catchment basin with which their works would have to deal. It has been considered as reasonable to take as a normal maximum run-off one-hundredth part of the average annual rainfall over the catchment area for 24 hours. Thus, if the average rainfall of the catchment area is 25 inches per year, it has been considered necessary to construct the drainage works to take off the equivalent of 0·25 inch per 24 hours. This is admittedly insufficient to deal with exceptional floods, but the cost of providing for a flood which might occur once in 50 years is entirely prohibitive. Taking the case of the River Thames, of which some accurate figures do exist, the largest flood recorded was due to very exceptional rainfall in the year 1894 when the discharge at Teddington Weir reached 20,236,000,000 gallons per day or 37,600 cusecs on November 18. This is equivalent to 15·24 cusecs[2] per thousand acres over the whole catchment area, or equivalent to 0·36 inch of rain on the whole area of the Thames Basin. In the 26 days from October 23 to November 17 of that year over 8 inches of rain fell in the Thames Valley, or an average of 0·31 per day. The River Thames when it is running bank high was able to discharge 4,500 million gallons per day—a quantity which has been exceeded on about 12 days per year since 1883. Improvement works later undertaken between Weybridge and Teddington enabled the river to discharge roughly double this

[1] These figures based on unpublished material supplied to me as United Kingdom delegate to FAO Conference in Rome, October, 1952.—L.D.S.

[2] Cubic feet per second. One cusec = 538,000 gallons a day and 1,000,000 gallons a day = 1·86 cusecs.

quantity. It is not considered practical to provide for floods of greater magnitude which are of very rare occurrence. Thus it must be accepted that some 150,000 acres in the catchment area of the River Thames are subject to inundation in times of high floods and that they must remain so subject. By way of contrast, the minimum flow recorded for the Thames at Teddington is 16,700,000 gallons per day or 31·0 cusecs on October 29, 1934.

Broadly speaking, it is only in the smaller catchment basins that a single day's heavy rainfall will be reflected in a serious flood. Thus in east Norfolk, one of the most disastrous floods on record of the river Wensum (on August 6, 1912) was due to a fall of rain of 7·3 inches in one day, though the river provided itself automatically with water storage by overflowing the lowland on each side to the extent probably of as many as 10,000 acres. Similarly the disastrous flood in August, 1952, which destroyed much of the Devon village of Lynmouth with a serious loss of life was due to a cloudburst higher up the tiny valley. Nine inches of rain fell in one day, most of it in three hours.[1]

Summarising the question of land drainage, it may be said that:

(*a*) Much land in the British Isles urgently requires drainage to render it of greater agricultural value.

(*b*) The channels of main rivers in particular require improvement so that they are able to take off up to about twice the amount of water which they can take off at present. Payment for such work that is considered necessary may be obtained by rates on the owners of land situated below the flood level, taken normally as 8 feet above the mean level of the river, but it is often contended that upland owners should pay for the privilege of discharging their surplus water with danger to lowland owners and that rates should levied over the whole of a basin.

(*c*) For purposes of dealing with the problem, and as a result of the Royal Commission mentioned above, the Land Drainage Act, 1930, provided for the division of England and Wales into the 47 catchment areas shown in Fig. 72 and for which Catchment Boards were constituted. The boundaries of these catchment areas are now regularly shown on all new issues of the 6-inch Ordnance Survey maps.

Water Supply.[2]—If it is the object of the land drainage engineer to drain the land effectively and conduct the water as easily and as quickly as possible to the sea, the object of the water supply engineer

[1] C. Kidson and J. Gifford, "The Exmoor Storm of 15th August, 1952," *Geography*, XXXVIII, 1953, 1–17.

[2] For matters relating to water supply the standard work is R. C. S. Walters, *The Nation's Water Supply*, 1936, which is a mine of information. For later statistics see successive editions of British Waterworks Year Book and Directory and the official publications already quoted.

is quite different. His purpose is to conserve a supply of pure, good quality water so that it may be available in quantity to the populace at large at all seasons of the year, independent of periods

FIG. 72.—Statutory Catchment Areas under the Land Drainage Act of 1930

At the time when this Act was passed there were about 1,000 statutory water authorities in England and Wales (borough, urban and rural councils, etc.) and about 1,000 water supply companies. Part of the object of establishing the statutory catchment areas was to secure better domestic water supply

of drought. The domestic and industrial water supply is derived in the main from three sources:

(*a*) Shallow or superficial wells which go down as far as the permanent water table, and from which the water can be pumped up.

(*b*) The deep wells which tap deep-seated supplies, including artesian water.

(*c*) River supplies, or gathering grounds whose water has been conserved in natural lakes or artificial reservoirs.

In country districts the normal water supply is still obtained to a large extent from wells, supplemented in many cases by supplies from natural springs. In 1914 out of 12,869 parishes in rural districts in England and Wales, only 4,874 had a piped water supply even to some of the houses. In 1939, according to the Scott Report, 3,432 parishes and at least a million of the rural population were still without piped water. In the same areas the method of disposal of sewage is by cesspools or pits in the ground, and the relative siting of well and cesspool is a matter of the first importance. There is in the underground water table a definite movement of water, usually, but by no means always, down hill by relationship to the surface of the ground, and obviously the cesspool should be on the down flow side from the well. Even with the utmost precaution pollution is likely to occur and with an increase in population the provision of a piped water supply is a first essential. The drilling of deep wells is perhaps most frequently undertaken by firms and individuals who wish to have an assured supply apart from that provided by water supply companies.[1] Where there are numerous wells drawing upon a deep-seated underground supply, particularly an artesian supply, as under London, it has become quite clear that the water is by no means inexhaustible, and the level of the artesian water under London has been lowered appreciably within the last 50 years. The problem of water supply is obviously most acute in the large conurbations. In many cases, as for example, London, provided the quantity of water removed does not affect the use for transport, navigation, and other interests of the riverine owners, it is possible to draw a water supply from all the larger rivers. In some cases the water is drawn directly from the river and simply passed through filtration plant before being distributed but in other cases it is drawn off first into storage reservoirs. Amongst the rivers whose water is used may be noted the Yorkshire Ouse and the Trent, the Wye, Severn and Bristol Avon, the East Anglian rivers and those draining to the Wash, the Tees and Derwent and many smaller rivers. The outstanding example, however, of the use of river water is that of the Thames for London. The bulk of London's water supply is taken from the River Thames above Teddington, supplemented by a considerable supply from the River Lea or the New River Waterworks and from wells. The springs and wells used to supply London from early times proved inadequate as early as the 16th century and the "New River Scheme" to bring water

[1] In England and Wales every landowner has the right to use, but not to sell, water naturally flowing through, past, or under his land provided there is no interference with the rights of neighbouring landowners.

from Chadwell and from Amwell near Ware in Hertforshire was sanctioned by Parliament in 1606 and completed in 1613. The River Thames water, more than two-thirds of the whole London supply, is taken off and stored in great reservoirs. Fears of a shortage have led to various proposals for distant supplies, notably from south-central Wales.

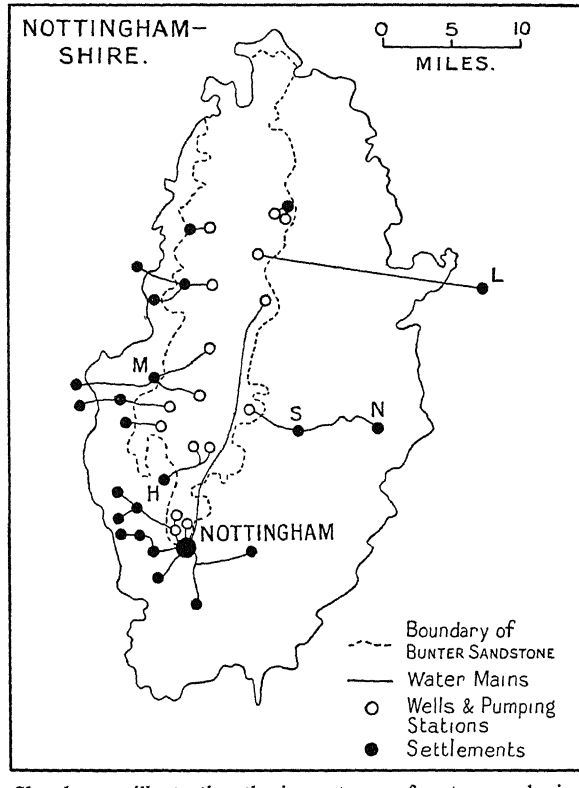


FIG. 73.—Sketch map illustrating the importance of certain geological horizons (in this case the Bunter Sandstone) as water-bearing beds (after Professor H. H. Swinnerton). The most valuable water-bearing formation in south-eastern England is the chalk, but many permeable or partly permeable beds such as sandstones and fissured limestones are locally important. Surface gravels are liable to pollution

In some of the other conurbations the problem is not quite so simple. Obviously the most suitable collecting grounds for water supply for a large city are the open moorlands or hilly areas which have a heavy rainfall, but where there is not a large animal or human population living on the hills which would naturally pollute the supply of water. Thus it is not too much to say that there has been a scramble amongst the more powerful city corporations to secure

rights for this purpose over the more thinly inhabited parts of Wales, the Pennines, the Lake District and elsewhere. There is great competition amongst the towns on the two flanks of the Pennines to secure the rights for areas of drainage and water supply from the Pennines themselves.

Water from the Pennines supplies the needs of over 20,000,000 people and reservoirs, as shown in Fig. 75, are closely spaced. But the supplies were obviously becoming inadequate. The Corporation of Liverpool cut the Gordian knot by damming up the previously

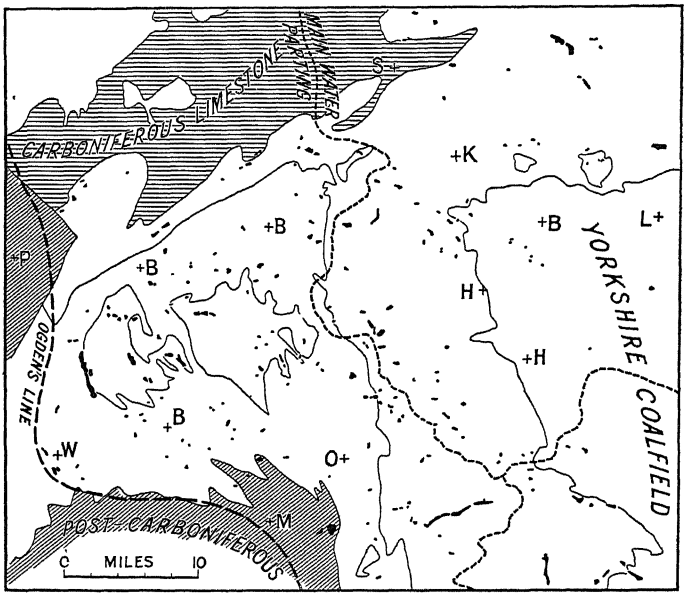


FIG. 74.—The Pennines as "gathering grounds" for water supply

All the black areas are reservoirs and no less than 220 are shown on this map. The blank areas are Millstone Grit and Coal Measures, on which nearly all the reservoirs are situated. The broken line in the west is the western limit of "soft" water (see Chapter XX)

rather uninteresting valley of Vyrnwy in Wales; thereby creating Lake Vyrnwy, with a surface 825 feet above sea level and forming the largest single inland sheet of water in Wales and at that time the largest artificial reservoir in Europe—5 miles long and on an average nearly a mile wide. It was constructed between the years 1881 and 1892, and has a surface area of 1,121 acres, its storage capacity being 12,131 million gallons, and the catchment area nearly 36 square miles. The aqueduct is 65 miles long. The Vyrnwy, it should be added, is the chief Welsh tributary of the river Severn, and was formerly a small stream meandering across a marshy flat. The suitability of the site depended to a considerable extent on the

hard old rocks of the neighbourhood forming a suitable foundation for the masonry of the reservoir dam. The Corporation of Birmingham followed suit by constructing a series of four reservoirs in the beautiful valley of the Elan about four miles west of Rhayader. These were completed in the years 1893–1904 at a cost of no less than £5,750,000. They cover 900 acres and yield a daily supply of 75 million gallons from a gathering ground of about 70 square miles, the storage capacity exceeding 10,000 million gallons. Provision

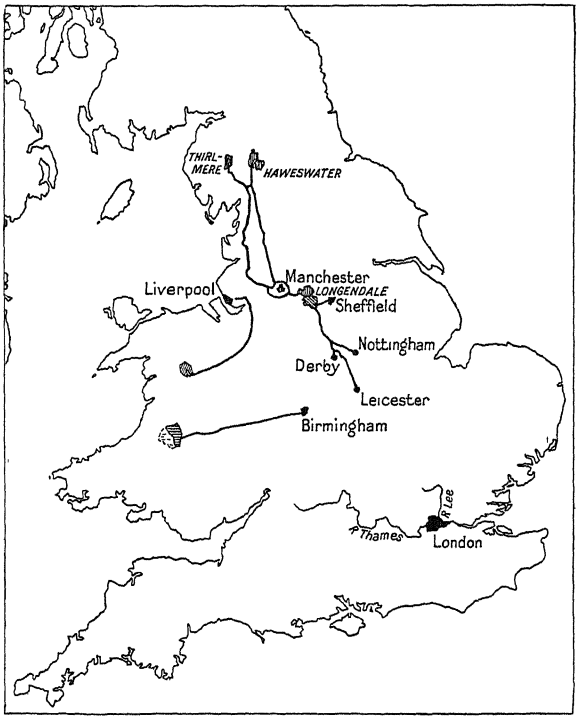


FIG. 75.—Map of England and Wales showing some of the long-distance urban water supplies

was made for later extensions of the supplies. From the reservoirs there are, of course, gigantic aqueducts, for the most part near the surface, though hidden, running for more than 73 miles. Parts of the aqueduct, totalling 37 miles, are actually siphons where the water is under pressure from the heart of Wales to Birmingham. In 1952 a further supply was obtained from the new Claerwen reservoir. Manchester has utilised the natural lake Thirlmere in the Lake District under the shadow of Helvellyn. A fear that the supply from Thirlmere would be insufficient for the growing city led to

the development of another scheme in the Lake District for using Haweswater. After about £1,000,000 had been spent, the scheme was postponed in 1932 as not at the moment necessary. This action gave rise to considerable discussion because it came just at a time when Hull had decided on a new scheme at a cost of £1,500,000 to obtain an independent water supply. Manchester had secured the rights to Haweswater against much opposition from those interested in local supplies. In a letter to *The Times* of November 18th, 1932, it was suggested that the time was ripe for a water grid all over the country corresponding in character to the electricity grid then being developed. It was suggested, for example, that a trunk main across the country using Haweswater for a supply would meet the future needs both of Manchester and of Hull, and that from this main there might be a southern extension to the dry areas of Lincolnshire, so removing the risk of drought from a country region still dependent upon wells. A continuation of such a main could pass through Cambridgeshire, Suffolk, and Essex, eventually connecting up with the London supply, and then continuing west and south to other areas of the country. The necessity for sharing available supplies had been accepted as early as 1899 when an Act of Parliament apportioned the waters of the Derwent valley between the cities of Leicester, Sheffield, Derby and Nottingham and the counties of Derby and Nottingham. Great works have been constructed on this basis of which the most noteworthy is the Ladybower Reservoir.

During the Second World War, the needs of agriculture for water became apparent and were stressed in the Scott Report. Although the Government accepted in 1944 the idea of coordinated national supplies, no definite scheme is yet in hand.

For certain industrial purposes, the quality or type of water is of importance. Thus it is well known that the supplies of soft water have in large measure been responsible for the location of the textile towns of Lancashire and Yorkshire, since soft water is so essential for washing and dyeing the raw materials and fabrics (see Chapters XIX and XX). But with the modern development of water softener, it would be relatively easy though expensive, for firms concerned to install the necessary apparatus, just as the railways already do for softening their water. Similarly, although the local well water from the gypseous Keuper Marls with its considerable permanent hardness was largely responsible for the development of the brewing industry at Burton, "burtonisation" or artificial hardening of water for brewing is now commonplace. For other purposes, too, soft water may be a disadvantage. If passed through lead pipes it is apt to dissolve so much lead as to become poisonous.

Transport.—The utilisation of British inland waterways for transport and navigation purposes and their linking by canals is

considered elsewhere (see Chapter XXVI). It may be noted here, however, that the land drainage engineer in embanking the rivers to prevent excessive flooding also benefits the users of waterways in that the firmness of banks is secured, and a deeper and narrower channel tends to be formed. Many of our rivers have been changed out of all recognition in this way. Thus it is difficult to imagine at the present time a ford across the Thames, as undoubtedly there was in early times, in the neighbourhood of London Bridge. The river has been so enclosed by embankments on either side that the current has become swift, and the actual watercourse deep. It may be appropriate to mention at this point, too, the enormous importance of the mouths of British rivers. The river mouths are often more important than the rest of the river because of the situation thereon of many of our great ports. Here the climate of these islands, with its well-distributed rainfall, is responsible for the steady flow of most of our rivers throughout the year. This, combined with the marked tidal scour consequent upon the large tidal range characteristic of the Continental Shelf round the British Isles, has been in a large measure responsible for the development of so many of our ports.

Water Power.—The hydro-electric power resources of the British Isles are not large. In the days before the extensive use of coal, small swift streams such as those running down from the Pennines were extensively used for driving machinery. The sites of the early forges and grinding works—for example in the Sheffield district—were definitely determined by the water power available from the streams. In the Sheffield area it is still possible to see the "hammer ponds" in which water was impounded and so used for turning water wheels which operated mechanical hammers for working the iron. Similarly the water was used for working the bellows in the forges. Some of the cotton mills in South Lancashire were likewise located, as were woollen mills in Yorkshire, where water power was available from the streams. In many parts of the country water power was used in small flour mills, but most of these primitive establishments have fallen definitely into disuse. A water wheel where such exists for grinding grain or for sawing wood has now become very definitely a tourist attraction, and more money is likely to be earned by the proprietor in providing teas for visitors than in any benefit he derives directly from his mill.

Some years ago the Board of Trade appointed a Water Power Resources Committee to enquire into the resources of the British Isles. They calculated that if all the schemes up before them were developed 250,000 kW could be generated out of which 210,000 were regarded as developable on an economic basis. The output would be equivalent to 1,840 million units or kilowatt hours per year, calculated to represent a saving of some 3 million tons of

coal a year. The figures given are for Great Britain, embracing Scotland (195,000), Wales (36,000), and England (26,500). This theoretical possibility was actually equal to 40 per cent. of the total units generated in 1917–1918. Since then the enormous increase in the demand for electricity has altered the picture completely.

By 1950 the quantity of electricity generated from water power in the United Kingdom had reached 1,300 million kilowatt hours per year, representing between 2½ and 3 per cent. of the total of electricity generated in the country. The increase in efficiency of steam generating plants had in the meantime reduced the saving of coal so that this quantity was officially stated by the Ministry of Fuel and Power to represent a saving of about 800,000 tons of coal a year. According to figures published by the Central Statistical Office the total generated in 1950 was rather in excess of the figure mentioned, and was given as 1,479 million units. It will be seen that this represents more than three-quarters of the total previously mentioned as possible, and it would seem that the old calculation was on the conservative side.

Under the Hydro-Electric Development (Scotland) Act, 1943, a public authority was set up known as the North of Scotland Hydro-Electric Board which was given wide powers for the development of water and the promotion of social, industrial and general rehabilitation within the Scottish Highlands. Its area of operations covers 22,000 square miles, approximately three-quarters of Scotland. The Highlands of Scotland have certain advantages for water power development. Temperatures are moderate so that risk of freezing is slight, evaporation is low, and hence the loss of water from reservoirs is small. There are many sites suitable for dams, and considerable areas are more than 3,000 feet above sea level so that a good fall of water is possible.

By 1952 the Board was operating 16 stations with a total capacity of 367,500 kilowatts and an average annual output of 874 million units. When the schemes under construction and being surveyed are completed by 1960 the total output of the Board's stations should be about 3,250 million units a year. This is greatly in excess of the figures previously calculated for the whole of Britain and would be more than sufficient to meet local demands for the whole of the Highlands, leaving a margin for export of about 1,000 million units a year for Central Scotland. Eventual saving in terms of coal is put at about 2 million tons a year. The cost of production per unit is less than that of steam operated stations. Amongst the important works are the Rannoch and Tummel Bridge stations in Perthshire, completed before the outbreak of the Second World War, and the Clunie and Pitlochry stations constructed after the war. The great Glen Affric scheme at Strathglass was opened in October, 1952.

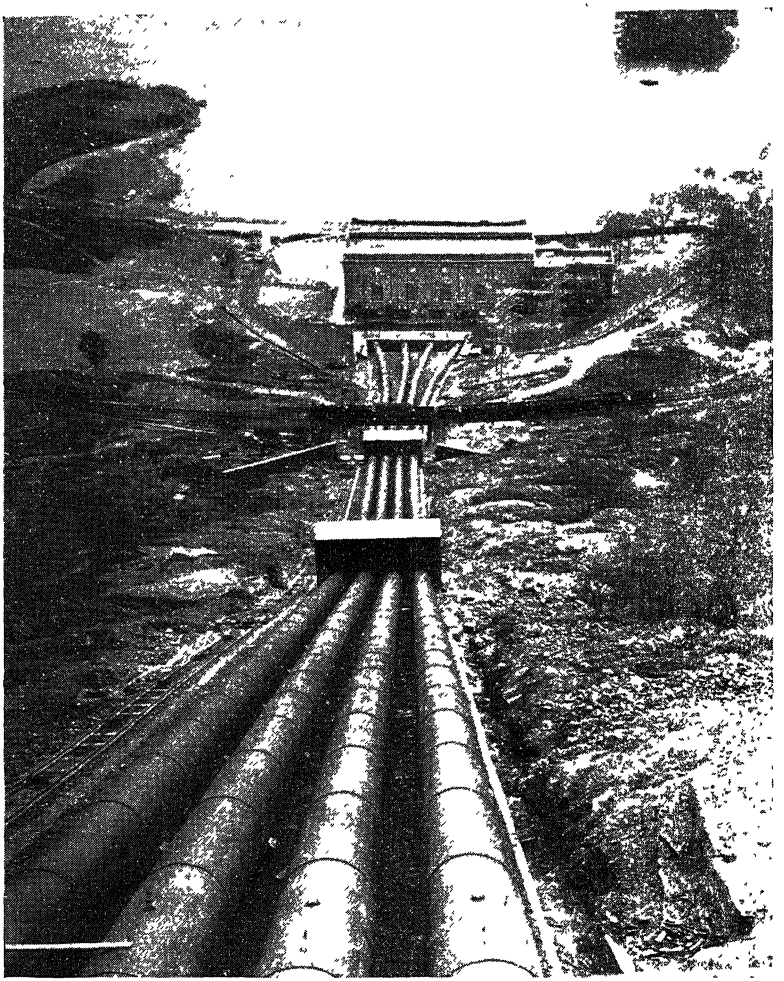
Outside the Highlands of Scotland conditions are generally less favourable, potential and actual output is of limited magnitude, so that the British Electricity Authority controls a limited number of relatively small stations. One of the largest is the Galloway Scheme in the Southern Uplands, completed at the end of 1936, with a generating capacity of 102,000 kilowatts and an annual output of about 180 million units.

There are hydro-electric power stations in North Wales at Dolgarrog, Maentwrog and Cwm Dyli, with a total output of 88 million units. Powers were granted in 1952 for the first two of these stations to be extended and others are possible in Wales, the Lake District and the Pennines; and possibly very small schemes in such areas as Dartmoor and Exmoor. With regard to some of the development in Wales and elsewhere objections are sometimes raised on amenity grounds since the proposed works would lie in National Parks.

What is happening is in fact the coordination in the whole national grid system (see Chapter XXIII) of what were formerly small isolated schemes, as well as some larger ones and extending or adding to them.

A very old scheme used the slight fall of the River Dee at Chester and supplemented until 1952 to a small extent the carbo-electric plant. In Scotland the falls on the Clyde supply two power stations, one using the Stonebyres Falls and the other the Bonnington and Corra Linn Falls. Developments in the Scottish Highlands date from 1896. The earliest station was erected at *Foyers*, on the eastern side of Loch Ness, in 1896, for the smelting of aluminium. The years 1907–1909 witnessed the erection of a 25,000 kw. power station at *Kinlochleven*, at the head of a marine loch, to which sea-going steamers have access. The water comes from the moor of Rannoch to the east. Quite a considerable town has grown up around the aluminium works, now belonging to Imperial Chemical Industries, which have been established. The Lochaber Power Company, established in 1921, achieved fame by driving a 15-mile tunnel to carry water from Loch Treig through the heart of Ben Nevis to near *Fort William*, there to generate electricity for the aluminium factory built just north of the town in 1929. Lochs Treig and Laggan are dammed to increase their storage capacity, and it is intended also to divert the headwaters of the river Spey into Loch Laggan. The *Grampian* system, begun in 1928 and completed in 1930 (Rannoch) and 1933 (Tummel), comprises two power stations utilising the abundant water-supply of the great Rannoch upland. The Rannoch installation uses water from Loch Ericht, and sends an overland power line to Abernethy, and so to Stonehaven, Montrose and Ballater; the Tummel station uses water from Loch Rannoch. Much farther north, in *Ross-shire*, the former Scottish Power Company has a station at Loch Luichart, using water from the river Conon, and supplying power to Nairn, Dingwall, and Dornoch.

Although scarcely falling under the head of hydro-electricity in the ordinary sense, the British Electricity Authority was planning in 1952 to develop a system known as "pumped storage." This consists of high level and low level reservoirs joined by a pipeline.



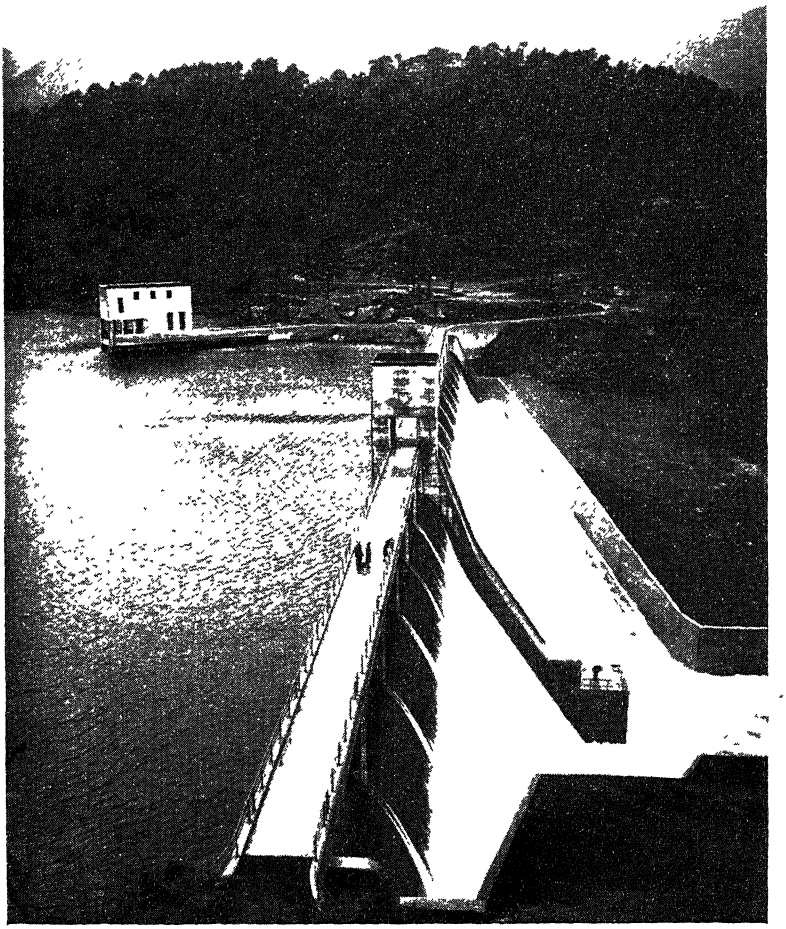
[*Photo Weekly Scotsman*

FIG. 76.—The Tummel Station

At off-peak periods the water would be pumped into the upper reservoir and then electricity could be generated by allowing the water to flow from the upper to the lower reservoir through turbo-generators at times of peak load.

Perhaps the most interesting possibility for water power lies in

harnessing the energy of the tides. Of the various schemes which have been considered that of the Severn Barrage has attracted most attention and has been the most carefully investigated. Unfortunately the output, estimated at 2,300 million units a year from a



[*Photo: Weekly Scotsman*

FIG. 77.—One of the new hydro-electric power stations in Scotland

plant capacity of 800,000 kW. would be rather irregular as the height of the tide varies. Capital cost was estimated at £29 million in 1933, at £47 million in 1944, and rising costs have since put the whole scheme virtually out of practical consideration.

The Shannon Power Scheme.—Until recent developments in the

Scottish Highlands, by far the largest and most ambitious scheme in the British Isles was that for harnessing the River Shannon. Ireland is practically devoid of coal, and so was under the necessity of importing her fuel, hence the great incentive to the construction of these power works which make Southern Ireland—the Irish Republic—virtually independent of imports of coal for many industrial purposes. The Government entered into an agreement with a German firm—Messrs. Siemens Schuckertwerke—in February, 1924, the proposals being submitted to Dàil Eireann in 1925, and the Shannon Electricity Act was passed in June of the same year. The River Shannon has a long meandering course over the central drift-covered plain, passing through three large lakes, Loughs Allen, Ree, and Derg, and in 125 miles of its length has a fall of only 55 feet, or less than 6 inches per mile. The flow is sluggish, the flooding of adjacent areas common, but from Lough Derg to the sea a remarkable change takes place. The surface of Lough Derg was about 100 feet above mean sea level at Limerick and from Killaloe at the southern end of the lake to Limerick is only a distance of 15 miles. The river made its way through a series of rapids, cutting almost a gorge through the hard rocks which there cross its bed. The local details of the scheme as carried out are shown in Fig. 71. By means of an embankment below Killaloe the surface of the lake was raised some 10 feet so that it is now 110 feet above O.D. Fortunately, Killaloe is built on rather higher banks of the river, and the little town has not suffered. At the southern end of the embankment a large weir was constructed, and then the bulk of the water taken through a canal or headrace to the power station just above Limerick where the full fall of nearly 100 feet could be utilised, the spare water being allowed to find its way through into the Shannon. The power house is at Ardnacrusha, from whence the race discharges the spent water into the Shannon near Limerick. The water in the tailrace is influenced by the tide, the net fall varying from 86 to 115 feet. The scheme was to be developed in two parts. The first part (which was completed in October, 1929) involved three turbine generators. Above Killaloe, throughout the Central Plain, the river is navigable and a barge canal was constructed at the side of the power works so as to permit continuous navigation from Limerick. Further a small canal with a

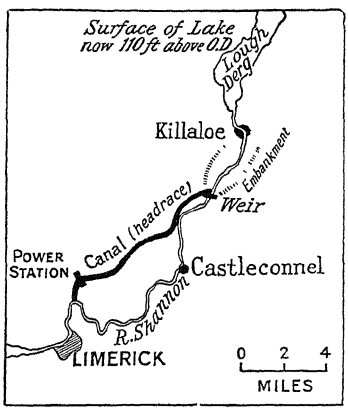


FIG. 78.—Details of the Shannon scheme

series of steps to be utilised by salmon was made, since salmon fishing in the Shannon is of very considerable value. The power generated at the power works is conducted by overhead lines to practically all parts of Eire and sufficient electricity has been generated not only to light the whole of Eire, and to run its existing industries, but also to make possible the development of new industries. The second part of the scheme involved three more turbines, but the

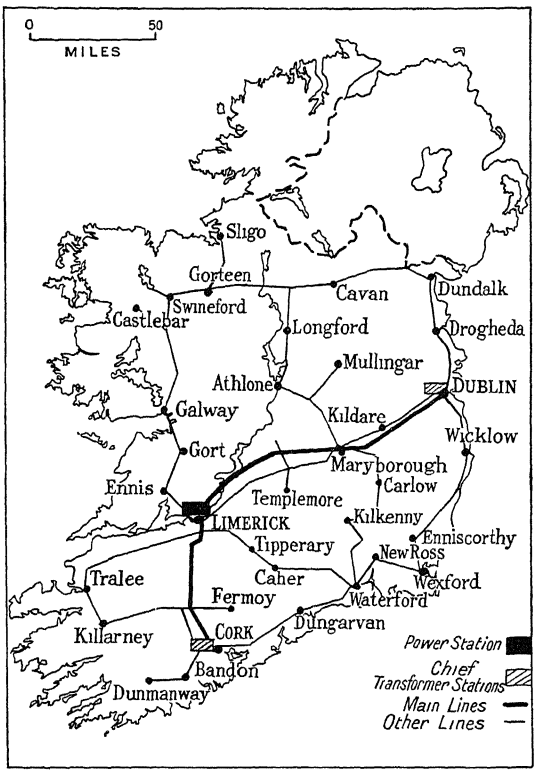


FIG. 79.—The Irish Electricity Grid, distributing power from the Shannon works

Shannon proved liable to very small flows of water in dry periods and it was not carried out.

Fisheries.—Most of the British rivers were once celebrated for their trout, their salmon, and for other fish. Many have become so polluted that the fish have disappeared, but in others fishing is very carefully preserved and the sporting rights guarded by angling societies and private owners. Fishing rights on the best trout streams in the south of England let at £5,000 per mile of stream. It is difficult to calculate the value of fresh-water fish in British rivers.

Possibly the value of salmon and other fish obtained in Ireland approaches £1,000,000 annually; the annual value of salmon from Scottish rivers is officially estimated at the same figure. In recent years increased attention has been paid to the restoration of inland fisheries by preventing further pollution. In the new hydro-electric power schemes it is now standard practice to provide fish ladders. In some, such as that near Pitlochry, the salmon are automatically counted as they ascend.

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CHAPTER VI

THE SOILS OF BRITAIN

PEDOLOGY, or the study of soils, is a study which as a modern science is still young, but much progress has been made since this book was first published. The soil is, broadly speaking, the surface layer of the earth in which plants grow. The mineral matter is in the main derived from the underlying rocks which have weathered and it might be thought therefore that this part of the soil would vary directly according to the character of the underlying rocks, and that therefore a geological map would form the necessary basis for the construction of a soil map. More and more of recent years however it has been recognised that climate plays a leading, even a dominant, part in determining the character of the surface soil. So much is this the case that it is possible to distinguish, as American writers have done, two great soil groups in middle latitudes. The *pedalfers* are those commonly formed where rainfall is in excess of evaporation, and where there is normally therefore a tendency for the more soluble mineral salts, including lime, to be dissolved out of the surface layers and washed downwards, leaving a soil rich in the elements aluminium (al) and iron (fe), hence the name ped-alfers. Where on the other hand evaporation exceeds rainfall there is an upward movement of moisture in the soil, and when the moisture is evaporated the previously dissolved salts are left behind in the surface layers, which thus become rich in such salts as calcium carbonate, hence the name *pedocal.* Where there is an approximate balance between rainfall and evaporation conditions are often particularly suitable for the accumulation of organic matter, and the development of a *chernozem,* or black earth.

It has already been noted in the preceding chapter on climate that in all parts of the British Isles rainfall normally exceeds evaporation, and hence the soils of the British Isles are normally pedalfers. Further, the whole of the British Isles lie in one climatic region, and that is not one of extreme conditions. Hence the soils of the British Isles do not show the great differentiation due to climate which is characteristic of such large tracts as the plains of European Russia, or of the heart of North America. Most of the soils of the British Isles thus belong to two of the great world soil groups, the podsols and the brown forest soils, together with a limited development locally of special types. Actually in the British Isles the soils vary enormously but according to parent material or human influence,

and Britain has thus despite the uniformity of climate a remarkable range of soils which are sometimes for obvious reasons described as "aclimatic."

The pioneer studies of soil in Britain were mainly the work of agriculturalists concerned in the use of soil. In 1793 a state-aided independent organisation known as the Board of Agriculture and Internal Improvement was set up, and it prepared a series of county studies each of which bore the general title "General View of the Agriculture of the County of X with Observations on the Means of Improvement." These were published first in a preliminary form, inviting comments, and later in a permanent form from 1794 onwards. In each the first chapter has a section devoted to soils, and most of the volumes include a soil map, sometimes a hand-coloured folding plate. In many of the counties of Britain this remains, more than 150 years later, the only soil map of the county. The descriptions of the soils were based primarily on texture, e.g. loams, clayey loams, black peat earths, and so on, with special types in certain counties such as the brashy soils on the Oolites, or descriptions which would be appreciated by farmers, such as "a turnip soil." These primitive soil maps are of such interest that they have been reproduced in black and white, sometimes simplified, in the County Reports of the Land Utilisation Survey of Britain, published under the title of *The Land of Britain.*

When the Geological Survey was set up in 1835 it was laid down as one of the objectives that maps of surface deposits and soils should be prepared to serve the needs of agriculture. For the most part this objective remained in abeyance, and although the Survey has now mapped the solid geology over the whole country, over large and important areas, including much of the Midlands of England, no drift map showing superficial deposits has yet been made. In a few areas the Geological Survey found time from its work of mapping geology to produce a soil map, the basis of which was the texture of the soil. Two coloured maps, covering a large part of Ayrshire, were published, and a soil survey was carried out of a considerable part of the Eden Valley in Cumberland. The maps distinguish such groups as light sand, heavy sand, light, medium and heavy loams, and so on, but a different scheme is adopted for each sheet. These maps are interesting because they represent a breakaway from a geological basis of classification and a return to the basis of texture.

An important landmark was the publication by His Majesty's Stationery Office in 1911 of *The Agriculture and Soils of Kent, Surrey and Sussex*, by A. Daniel Hall and E. J. Russell (afterwards Sir Daniel Hall and Sir John Russell). They were concerned with the soil as a medium for farming and their mechanical analyses were based on a well mixed sample of the surface layers, a procedure entirely different from the modern methods which study the separate

layers in the soil, or the soil profile. The foundations for the modern concepts of pedology, or soil science, were laid particularly by the Russians and by the Americans under the leadership of the late C. F. Marbut.

The move in Britain to establish a separate soil survey and to carry out detailed studies and mapping on the 6-inch scale developed slowly, but in due course, shortly before the outbreak of the Second World War, a Soil Survey of England and Wales was established, with the late Professor G. W. Robinson as its first Director.

Under the Agricultural Research Council, through the Soil Survey Research Board, the Soil Survey of Great Britain is now engaged in detailed mapping in England, Wales, and Scotland. The Annual Report is published by the Stationery Office, and the Report for 1951 shows that detailed surveys had been completed for two of the small series 1-inch sheets in England, and eight in North Wales; and that detailed surveys were in progress covering another six of the sheets. Since there are 360 to cover England and Wales it will be seen that a start is really only now being made. Similarly in Scotland detailed surveys were completed in three and in progress in eight out of the 131 sheets concerned. It is also interesting to record that the basis of classification of soils being used for the Scottish sheets differs from that for England and Wales, an indication that modern soil scientists are as yet by no means agreed.

The Soil Profile

There is however general agreement on the importance of studying the soil profile. The parent material of the soil may be the underlying rock, using the word "rock" in the geological sense, and independent of hardness. In some cases the soil is simply the surface layer of the rock and the two merge imperceptibly into one another, as for example the soils which overlie river alluvium or clay. But in many cases mechanical weathering has broken up the underlying hard rock into smaller fragments, and chemical weathering due to the solvent action of rainwater has played its part. On almost all slopes there is soil creep, the soil sliding or being washed downhill, so that especially towards the lower slopes of valleys there is a layer of transported material from a few inches to several feet in thickness between the soil and the underlying rock, and it is this hillwash which forms the true parent material in the soils.

The normal climatic conditions in Britain result in the differentiation of three layers, or horizons. The upper, or A, horizon is subject to downward washing or leaching; the finer material is washed down mechanically and soluble constituents are gradually removed in solution by the percolating waters. The result is to leave a greyish

or whitish layer of insoluble quartz sand or rock fragments. Between this whitish layer and the surface there may actually be two thin levels, that at the surface (Ao horizon) being dark or almost black and owing its colour to remains of vegetation, humus and sometimes to sooty material from forest or heath fires. Below this the A_1 horizon, though suffering from leaching, remains dark because it receives from above the addition or organic matter. Then follows the main leached A_2 horizon. Below the A horizon is the B horizon often stained brown from oxides of iron, redeposited by the percolating waters from above. The iron oxides may actually form concretions or even cause the consolidation of the level to form a hardpan. The fine mineral particles washed down from above may cause this B horizon to be quite different mineralogically from that above. The C horizon is that of the weathered parent material.

This division of the soil profile into A, B, and C horizons is characteristic of the great world soil group known as the podsols. It may be regarded as normal in Britain in all but the wettest parts where there is impeded drainage and perhaps the drier parts of the east. Actually the podsol profile is broken up wherever the land is ploughed and is therefore seen developed naturally only in sandy heathland or under coniferous woodland. In wet regions such as the level floors of valleys the permanent water table is near the surface and the horizons are somewhat different. Again the surface, or A, horizon may be leached but the intermediate, or B, horizon is saturated for part of the year and relatively dry for the other. As a result oxidation and reduction alternate, producing a characteristic mottling of grey or yellow or brown which is a sure sign of impeded drainage. Below it in the C horizon air cannot penetrate and the conditions are permanently reducing so that greys and blue greys predominate. This is the characteristic profile of the gley or glei soils, though some writers restrict the term gley to the mottled horizon.

In the drier parts of southern and eastern Britain there is less difference between rainfall and evaporation and leaching is less intense. In certain summer months evaporation may even exceed rainfall. It is here that deciduous woodland normally predominates and the annual leaf fall provides a surface layer of brownish humus in contrast to the acid black humus of the podsol. Such soils are commonly known as brown earths or brown forest soils and the effect of ploughing and cultivation is normally to promote the development of a soil of brownish colour and to prevent the development of a podsol.

It may thus be said that there are three major soil groups present in Britain—the podsols, the brown earths and the gley soils. Under special local conditions other groups such as peat soils or fenland soils may be present whilst in the hills and mountains the weathering

of the old rocks has not proceeded long enough to provide the necessary basis for a proper soil profile. In such areas the so-called immature soils are found. In other cases the surface layers may be washed away with the result that some soils are described as having a truncated profile. Some very interesting soils occur on limestones, particularly chalk. Although there is always an excess of lime in the subsoil, B and C horizons, the surface layer may be so leached as to be even acid in reaction.

Soil Series

Within the great world soil groups one of the most commonly used units of classification, comparable perhaps with the genus amongst plants or animals, is the "soil series." This is defined as "a group of soils derived from the same or similar parent materials under similar conditions, and showing similar profile characteristics." It is the soil series which is now commonly mapped in detailed soil survey, and the series are named very often from localities where they were first studied—and the names are unfortunately not, therefore, descriptive. It should be noted that a soil series may include a considerable range of texture and may also include shallow or deep phases so that from the point of view of cultivation a single soil series may embrace land of very different quality agriculturally.

The description of each soil series is based upon the character of the profile. Since ploughing and cultivation generally prevent the formation of a profile it is somewhat difficult to fit agricultural soils into this classification. Consequently there is much still to be said in favour of the older approach to the study of soils which was concerned particularly with the texture, the structure and the chemistry. The Scottish surveyors still recognise the overriding importance of the geological background and are grouping their soil series into associations which have a close relationship to the underlying geology. In England and Wales on the other hand the surveyors are mapping soil series and do not recognise the same type of grouping into associations.

As no detailed soil survey has been carried out over the greater part of the British Isles to date efforts to show British soils on small scale maps leave much to be desired. An attempt has been made by H. Stemme in his Soil Map of Europe. This map is useful as a first approximation, but has been severely criticised by the soil scientists.

We may now proceed to look at British soils from what may be called the older point of view.

Broadly speaking, it may be said that four factors have determined the distribution of the different types of soil in the British Isles.

(1) *Parent material, including solid rocks and drift.*—We have seen that five-sixths or more of the British Isles were at one time or

another covered by great ice sheets, that the ice sheets removed soil from over huge areas, mixed fragments of rock of very varying character, and eventually distributed over the surface of the land a mantle of deposits of very varying thickness which are collectively known as drift. Quite a large proportion of these drift deposits were further re-sorted by water action—in some cases by waters derived from the melting of the ice, in other cases by more recent streams. It may even be that some of the finer particles were partly re-sorted by wind or by wind and rain. What is of fundamental importance is that these surface deposits are very widespread. The geologist who is concerned mainly with the structure of the earth's crust tends rather to regard these mixed drift deposits as of little importance, very often as a distinct nuisance in that they obscure the character of the underlying solid rocks. They are very varied, difficult to classify, and not perhaps very interesting to study in detail in themselves. Thus the geologist who deals with the solid rocks underlying the drift deposits often ignores the drift, and it is significant that there is not in existence at the present day a complete map of England and Wales which shows the distribution of drift deposits.[1] In some of the eastern counties, particularly in East Anglia where they assume a huge importance, they have been mapped, and the Geological Survey publishes quarter-inch maps of this part of England in two editions, one showing the solid rocks with the drift removed, and the other showing the drift deposits as they actually are. The drift deposits assume a still greater importance in Ireland, and many years ago a general geological map of Ireland was brought out showing the

FIG. 80.—The drift-covered areas of England and Wales

The stippled areas are almost wholly drift covered: the black areas would be submerged if the drift and later deposits were removed. (After L. J. Wills and G. W. Lamplugh)

[1] This is not, of course, true of the modern maps prepared by the Geological Survey and published on the scale of one inch to one mile. These are published in two editions, Solid and Drift, and are magnificent examples of detailed work but they do not cover the whole country.

distribution of drift deposits.[1] Because of the absence of a general drift map of Great Britain the geographer is too often thrown back on the solid geological map, and it is a fundamental, but a very common, error to suppose that this is a satisfactory basis for studying the soils of England, Wales, and Scotland. In the southern counties, which were little affected by glaciation, this may sometimes be the case, but north of the Thames it certainly is not.

FIG. 81.—The principal boulder clays of eastern England (after F. W. Harmer, *Geology in the Field*)

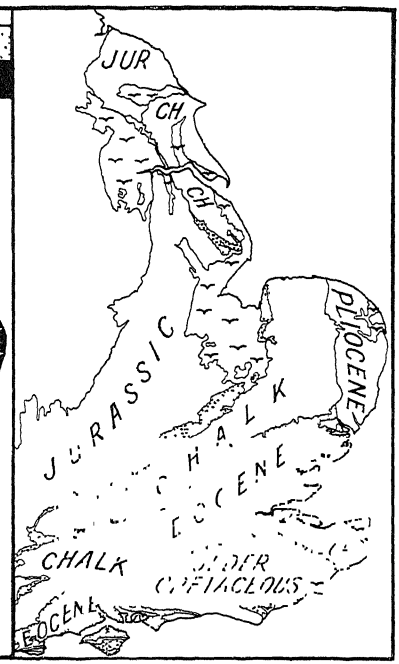

FIG. 82.—The solid geology of eastern England

Where drift deposits are absent, or where the drift is very thin, then the character of the underlying rocks is of the greatest importance in determining the type of soil. Thus the stiff Weald Clays give rise to the stiff clay soils of the Wealden area, the sands of the Lower Greensand to sandy soils, and so on; but it is a mistake to pay too much slavish attention to the geological map, for the poorer siliceous soils of the Highland belt, as for example of Wales, vary but little in character whether they are derived from Cambrian,

[1] *Surface Geology of Ireland* (10 miles = 1 inch), by Sir A. Geikie (Bartholomew).

Ordovician, or Silurian rocks, although there may be considerable variation *within* any one of these groups or in rocks of the *same* age in different parts of the country.

(2) *Climate*, including soil climate. On the whole, of course, there is a general increase in the amount of rainfall as one goes from east to west in the British Isles. On the whole there is a general tendency for peat formation to increase as one goes in the same direction. An important point, not always realised, is that one must regard the rainfall of a considerable part of the British Isles as excessive; even if drainage operations were undertaken it is likely that the climatic conditions are such that the soils would not even then be suitable for arable farming. This applies, for example, to many parts of the Highlands of Scotland.

(3) *Vegetation*, including former vegetation.—The former vegetation cover of numerous areas plays an important part in the character of the soil which is found at the present day.

(4) *Relief*.—The degree and direction of the slope of the land is important in its relation to drainage.

It has been found that a distinction must be drawn between the texture of a soil and the structure of a soil. When organic matter has been eliminated it is possible, as indicated above, to separate the mineral particles of the soil according to size, that is to determine differences in texture.

If however we take an ordinary worked agricultural or growing soil, dry it thoroughly and, say, place some in a closed jar, it is found that the particles remain grouped together and give the soil what is commonly called a "crumb structure." The soil does not immediately break down into a powdery mixture of large and small particles. This crumb structure is recognised as being of enormous importance where growing plants are concerned, and the maintenance of a good crumb structure is what the farmer understands by "keeping the soil in good heart."

Certain modern methods of soil treatment, notably the patented substance known under the trade name of Krilium aim at creating a suitable crumb structure in heavy soils which are otherwise almost amorphous clay.

A great deal of nonsense is written about the relative value of artificial or chemical fertilisers which add to a soil the chemical nutrients required by plants, and natural or animal manure. There are those who go so far as to say that for good health vegetables and fruits must be grown on land enriched with natural manure. Whilst it is difficult to substantiate such an extreme point of view it is probably true that animal manure helps to maintain the crumb structure of a soil whereas that crumb structure may be broken down by the addition of chemical fertilisers alone.

We may now attempt a classification of British soils, especially

in relationship to their effect on agriculture and the natural vegetation cover. Two broad groups are to be distinguished:

(1) Mineral soils.—Those which owe their principal characteristics to the size and character of the mineral particles present.

(2) Organic soils.—Those whose dominant characteristics are determined by the character and relative quantities of organic compounds present.

(1) **Mineral Soils.**—Apart from the presence or absence of calcareous material, the properties of mineral soils are determined largely by the proportion of particles of different sizes. For purposes of study particles have been grouped arbitrarily under the following types:

Diameter above 2 mm.—stones.
Diameter between 0·2 and 2 mm.—coarse sand.
Diameter between 0·02 and 0·2 mm.—fine sand.
Diameter between 0·002 and 0·02 mm.—silt.
Diameter below 0·002 mm.—clay.

Sandy soils usually contain more than 60 per cent. of coarse and fine sand and less than 10 per cent. of clay. Owing to the large size of the particles they present but a small surface for retention of water; they are easily permeable by air and also by water, and hence plant roots can not only penetrate such soils easily but can also "breathe" easily. Water may drain rapidly away from the roots and so the plant roots may suffer from drought. On the other hand these soils are easily cultivated, but not infrequently are deficient in plant foods because the freely moving water dissolves the plant foods and removes them. For that reason they are called "hungry" by the farmer.

Loamy soils contain a smaller percentage of coarse and fine sand, but a larger proportion of silt and clay. They are less easily permeable, but sufficiently so to allow the ample aeration of roots and to prevent waterlogging. Thus loamy soils are suitable for all types of crops and are the most valuable of the mineral soils.

Clayey soils, or clays, containing a high proportion of clay are much less permeable, liable to become waterlogged, very sticky when wet, but hard and difficult to cultivate when dry. It is usually difficult for plant roots to penetrate clay soils, whilst in the summer months when the clay soil is dry and cracked the roots may be torn asunder. They are thus not naturally very suitable for arable cultivation (though they can be much improved by liming and addition of organic matter) and in Britain are very largely given over to permanent grassland. Many of the "marginal lands" of Britain, once cultivated, but where now cultivation is uneconomic, have clay soils.

Calcareous soils.—Calcium carbonate and calcium phosphate

are both of vital importance to a plant, and in small quantities they usually tend to improve the character of any soil, especially a clayey soil. The term marl is variously applied in Britain, but is sometimes, and rightly, given to a loamy soil or a clayey soil which has a considerable proportion of calcareous material. In soils derived directly from limestone, such as chalk, the proportion of calcium carbonate may naturally be very high. On such soils occur plants which are definitely calcicolous, or lovers of lime, whilst on other types of soil calcifugous plants, or haters of lime, occur—especially on acid soil types. It may be noted here that in some cases the soils found in limestone areas are curiously deficient in calcium carbonate, the whole of it having been leached out by the solvent action of percolating rain-water.

Other types.—Mention should also be made of those soils which have special characteristics due to the presence of quantities of salts—for example, the salt marshes—whilst a separate category must be preserved for rocky soils or hard rock, not covered by loose earth or by soil in the generally accepted sense.

(2) **Organic Soils**

Fenland, or black earth, soils.—The organic matter in soils is, of course, derived mainly from plants. When plants die the very varied organic compounds of which they consist are very rapidly attacked by the various micro-organisms in the soil which tend to break them down again into simple compounds, such as carbon dioxide, water and ammonia, the ammonia rapidly becoming oxidised to form nitrates. But there are other organisms in the soil which build up their own substance and also reconstruct complex organic compounds. In a well aerated soil a great variety of micro-organisms is present, giving rise to innumerable substances of organic origin, varying from the complex organic compounds formed by the decaying plants themselves to the simpler compounds and elemental substances which result from their final alteration. Among the most characteristic of the intermediate products present are those compounds, usually black and sticky, collectively known as humus. They are colloidal like clay, but, unlike clay, they do not make the soil sticky; on the contrary they render it more friable. A loamy soil with a good proportion of humus may be described as the most fertile of all soils, and where the Fenlands of England have been drained are some of the most fertile agricultural lands anywhere to be found, and it will be noticed that the characteristic colour of the soil is almost black, due to the large proportion of humus present.[1] Where, however, the aeration of the soil is deficient, usually due to the excess amount of moisture, then there tends to be an accumulation, not of humus but of humic acid.

[1] Though humus is dark in colour some of its constituents are not,

Peaty and moorland soils.—In peaty and moorland soils the great defects are acidity due to the excess of humic acid and poor aeration, in turn due to excessive moisture and low temperatures. In some cases by draining, or by the admixture of a proportion of calcareous material, a peaty soil may be converted into a very rich humic soil, but there are other areas where the acidity is so great that the expense of treatment is prohibitive even by these simple means.

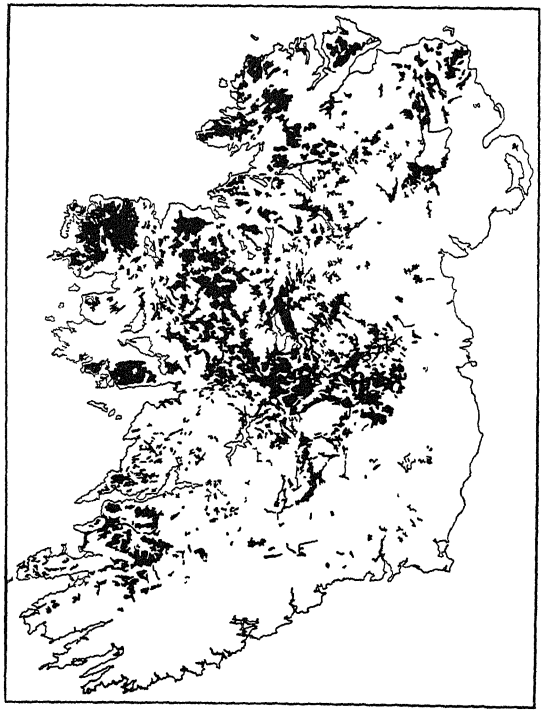

FIG. 83.—The peat-bogs of Ireland

All areas in solid black are covered with peat and bogland. The predominance in the Central Plain and in the West should be noted

This, of course, is particularly the case in moorland areas where the drainage is bad.

Perhaps a better classification of organic soils would be:

(*a*) Mild humic soil or mull, such as is normally found on the floors of deciduous woods, in meadows, gardens, etc., and has a neutral reaction or is only slightly acid or alkaline, being well aerated by earthworms, etc. (Brown Earth.)

(*b*) Fen or mild peat, formed where there is an excess of water but a deficiency of oxygen, as on the margins of lakes; but the water gives an alkaline reaction because of the presence of lime

or other bases in quantity. When drained this is the rich humic or the black soil of the Fenland area.

(*c*) Raw or acid humus is formed on soils deficient in lime and is characteristic of podzolised soils under coniferous woodland and on dry heaths. Oxidation is not necessarily deficient, but the soil must be so acid that the humus is unsaturated and earth-worms are absent.

(*d*) Acid peat. Under conditions of excessive moisture, low temperature and oxygen deficiency acid peat accumulates and a pure peat soil is produced. If the conditions are maintained this acid peat soil may reach a great depth giving the characteristic moor ("mor") soil with moorland vegetation.

The Distribution of Soil Types in the British Isles

1. *Mineral Soils derived from Drift deposits.*—The deposits left behind after the retreat of the ice sheets of the great Ice Age vary enormously in character. The following broad types of soil derived from these and other superficial deposits may be distinguished:

(*a*) *Boulder Clay.*—This is usually a stiff clay with numerous boulders of rock of very varied size transported from a distance. As a rule the soils derived from Boulder Clay are stiff heavy clay soils and hence little cultivated but rather left as grassland. In the wetter parts of Scotland and Ireland particularly they tend to be waterlogged and to give rise to acid humus soils or acid peaty soils. The same happens with compact soils even if not true clays.

(*b*) *Chalky Boulder Clay.*—A special place must be made for the boulder clay, common in parts of eastern England, where there is a considerable admixture of chalk. This ameliorates the normal character of the clay soil derived, and the chalky boulder clay is frequently very fertile (see pp. 236–237).

(*c*) *Loamy Glacial Drifts*, such as those derived from the Old Red Sandstone in Scotland and in parts of England. Because the soils are well mixed they may be very fertile and hence the land is largely cultivated. This is the case in the Lothians of Scotland around Edinburgh.

(*d*) *Glacial Sands.*—Particularly conspicuous in Ireland are the dry grass-covered gravel ridges, known as "eskers," and the sandy, loamy or stony, sometimes clayey, knolls of glacial drift called drumlins. Where the sands are coarse and the water drains away quickly the soils are light and sandy, but the drumlins are often selected in Ireland for agricultural purposes because of the better drainage when compared with the low-lying levels by which they are surrounded.

(*e*) *Brick-earth.*—In the south of England there are some fine

loamy or silty soils which are derived from what is commonly called brick-earth. Brick-earth (cf. French *limon*) seems to be in the main composed of the finest particles which result from glaciation, probably distributed partly by wind and thus corresponding to loess, but re-sorted under conditions of heavier rainfall in England, and so differing in character from typical loess. Soils derived from brick-earth are, however, very fertile.

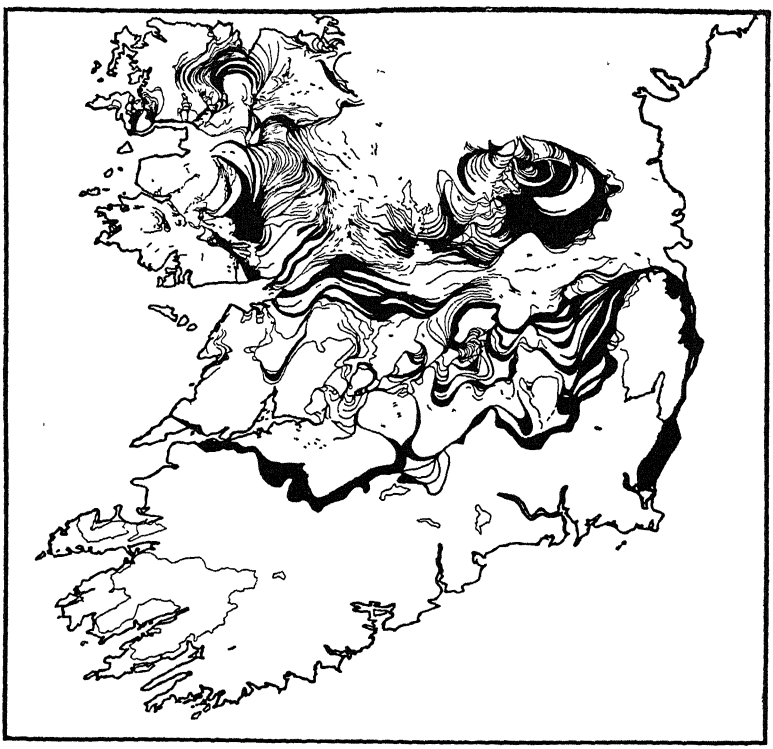

FIG. 84.—The Irish eskers—ridges of gravelly or sandy material of glacial origin (after J. K. Charlesworth, *Geography*, XVI, 21–27)

(*f*) *Gravelly Soils.*—There are numerous sheets of gravel both at high levels and at low levels, particularly in England, some of which may be derived from outwash fans when the ice had melted, others of which are the normal deposits of rivers and some perhaps coastal deposits laid down under marine conditions. The high level gravels often give rise to infertile soils whereas the low level gravels, especially if covered by a thin layer of brick-earth, may be particularly fertile. Special reference will be made later to cultivation on such areas as the Thames terraces.

(*g*) *Clay with Flints.*—A special type of deposit is widely distributed on the surface of the Chalk Downs, especially the North Downs of Kent. It consists of a stiff clay, brownish in colour, with sharp angular flints. All the lime has been leached out so that it is a stiff clay soil deficient in lime, commonly, therefore, left to grassland or to damp oak woodland contrasting with the surrounding chalk country itself.

(*h*) *Alluvium.*—The fine grained deposits of the alluvium of flood belts and riverine tracts need no further description, except to point out their wide distribution in this country. To them may be added the fine marine silts such as are important round the Wash.

2. *Mineral Soils derived from the underlying Solid Rocks themselves.*—Two broad divisions may at once be distinguished:

(1) The siliceous soils derived from the older rocks, mainly Palæozoic rocks, of the "Highland Zone" (see p. 25) of the north and west of England and Wales, Scotland and Ireland. Although technically they may be classified into sands, loams and clays, according to the size of the particles, they tend to differ from the better known soils derived from later rocks in the southern and south-eastern parts of England. They are comparatively well drained, but usually lack the fertility of soils derived from later rocks because the weathering processes have failed to form soils of great depth. Where drainage is bad and moisture excessive peat and moorland soils predominate, as, for example, in many parts of the Highlands of Scotland. Indeed the soils of Scotland derived *directly* from underlying solid rocks seem to be limited. Amongst the soils derived from the Palæozoic rocks are extensive stretches of limestone soil, as in parts of the Pennines.

(2) Soils derived from the younger Mesozoic and Tertiary rocks of the "Lowland Zone" (see p. 25) of the south and east of England. Of the Secondary rocks the marls of the Trias and the clays of such belts as the Lias and the later Jurassic rocks, the Cretaceous of the Weald and the Tertiaries (*e.g.* London Clay) give rise to tracts of heavy clay soil. Between these there are the ridges formed by the outcrops of sandstone and limestone. On these will be found sandy soils, as on the Lower Greensand, and the calcareous soils characteristic of the Oolitic Limestone and of the Chalk. Again, it must be remembered that on these limestones, including the Chalk, leaching is often important and lime may be practically absent. What is often important is the rapid and very marked local variation in many parts of the Lowland Zone, *e.g.* the London Basin.

3. *Organic Soils.*—The distribution of organic soils in the British Isles will have been made clear from the descriptions given above.

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CHAPTER VII

LAND USE IN THE BRITISH ISLES

IN England and Wales the Ministry of Agriculture and Fisheries is responsible for collecting and publishing in outline statistics showing the principal uses of the land of the country. In Scotland the same function is performed by the Department of Agriculture for Scotland; in Northern Ireland by the Ministry of Agriculture; and in the Irish Republic by the Department of Agriculture. In England and Wales every year "the Minister of Agriculture and Fisheries requires a return in writing to be made" by each owner or occupier of agricultural land exceeding one acre in area, specifying the acreage of the several crops and of land in fallow or used for grazing, the number of live-stock on the land and the number of persons employed thereon on June 4. Similar returns are made in Scotland, Northern Ireland and in the Irish Republic. The returns so made are strictly confidential, but the acreages given are added together for each parish and parish figures may be obtained on payment from the Ministry concerned. The published statistics refer to administrative counties. In addition the Forestry Commission collects statistics of forest, woodland and plantations in England, Wales and Scotland, so that the acreages of these are available from time to time.

Combining the statistics available and expressing the figures in percentages of the whole areas the following tables show in comparative form the use which was made of the land of the British Isles in the depression year 1933 and for the year 1950 when the country was still faced with the need of maintaining food production from agricultural land.

YEAR 1933

	Woods and plantations	Rough grazing land	Permanent pasture	Arable	Other land
	per cent.	per cent.	per cent.	per cent.	per cent.
England	5·1	11·3	42 8	26·5	14 3
Wales	5 0	33·8	41·8	11·9	7·5
Scotland	5·6	66·8	8·3	15·9	3·4
Great Britain					
Northern Ireland	1·3	15 7	45·6	27·9	9·5
United Kingdom					
Irish Republic	1·4	12·0	47·3	21·4	17·9

YEAR 1950

	Woods and plantations	Rough grazing land	Permanent pasture	Arable	Other land
	per cent.	per cent.	per cent.	per cent.	per cent.
England . . .	5·8[1]	8·0	28·2	40·0	18·0
Wales	6·2[1]	27·4	29·1	21·1	16·2
Scotland . . .	6·6[1]	57·3	6·2	16 8	13·1
Great Britain . .	*6·6*	*29·0*	*20 8*	*30 6*	*12·8*
Northern Ireland .	1·7	21·2	32·6	36 0	9·5
United Kingdom .	*6·4*	*28·7*	*21·4*	*30·8*	*11·7*
Irish Republic . .	1·7	—[2]	44·7	23·3	30·3

[1] Census, 1947 [2] Not specified

The tables demonstrate at once certain salient points. In the first place there is the extremely small area actually covered by woods, forests and plantations in all parts of the British Isles. Forest and woodland actually occupy a smaller proportion of the surface in the British Isles than in any other important European country. This is notwithstanding the fact that the natural vegetation of the greater part of the British Isles is forest, and two thousand years ago forest must have covered the greater part of the country at least below the 1,000-foot contour. Further, it is curious because, to the casual observer, the British Isles still appear to be well wooded. This, of course, is very largely due to the numerous small woods, shaws, and hedgerows with isolated trees, as well as the large proportion of parkland which is so characteristic of the country, especially in the south-east. It must be admitted that the position until recently was little short of a scandal when one has a country which is essentially one which could be forest-covered and which has incredibly large tracts of moorland or heathland which might well be productive of good

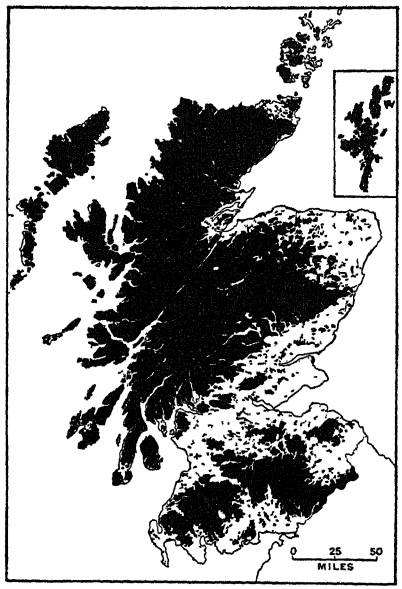

FIG. 85.—The moorland (or rough grazing land, including deer "forests") of Scotland

timber. Furthermore, the woodland that does remain is, from the forestry point of view, often seriously neglected. Further reference will be made to this subject in a special chapter. The rough grazing land referred to in the second column is for the most part heathland and moorland occupying upland tracts. In England a considerable percentage represents land on the Pennines, the upland areas of the south-western peninsula and the heaths of south-eastern and central England. In Wales the much higher proportion reflects the large extent of moorland in the mountainous areas. It is scarcely surprising to find two-thirds of the surface of Scotland listed as rough grazing land in view of the large extent of the Highlands and of the Southern Uplands. Lowland Ireland, with its improved pastures, has on the other hand comparatively little rough grazing. By adding together the figures for permanent pasture and arable land one gets the proportion of the country which may be regarded as improved farming land—nearly two-thirds of the whole in the case of England, only a little over half in the case of Wales, only a quarter in Scotland, but approximately three-quarters in both the Irish Republic and Northern Ireland. Perhaps the most interesting column in this table is the last one, headed "Other land," for which official details are not available. It is curious that until recently we had no statistics as to what exactly is the use made of a seventh of the surface of England.

A comparison of the two tables overleaf shows in 1925 72·3 per cent. of the surface of England and Wales and 74·2 per cent. of Scotland was agricultural land of which particulars were furnished annually by owners or occupiers, whereas in 1950 the totals had been swollen by the inclusion of open grazing in common ownership. If one takes improved farm land only (crops and grass) the total in Great Britain (England, Wales and Scotland) had dropped from a total of 30,450,000 acres in 1925 to 28,845,000 in 1950. This is a loss of 1,605,000 acres in 25 years or 64,200 acres a year, despite the reclamation of former rough grazings and is a measure of the spread of industry and housing as well as mineral working and defence areas.

The total land area of the United Kingdom (England, Wales, Scotland and Northern Ireland) is 59,533,000 acres or 93,021 square miles. On this area live 50,423,668 people according to the 1951 census. This means that the share per head of population of land of *all types* is a little over $1\frac{1}{8}$ acres per head. The acreage per capita of improved farm land (crops and grass) at 31,126,000 acres is only 0·6 acre. If England and Wales are considered apart from Scotland and Northern Ireland, it is only 0·85 acre of land of all types or 0·55 acre of improved farm land per head. Taking the world as a whole the land area represents about 14 acres of land of all sorts per head of population of which rather over 1 acre is

AGRICULTURAL STATISTICS OF THE BRITISH ISLES, 1925

	England and Wales	Scotland	Northern Ireland	Irish Republic
	Acres	Acres	Acres	Acres
Area exclusive of inland water and tidal land	37,136,000	19,070,000	3,351,500	17,024,500
Arable	10,682,000	3,229,000	573,800	1,552,000
Permanent grass	15,073,000	1,476,000	1,217,300	10,704,000
Rough grazing (private)	1,104,000	9,250,000	514,500	not recorded
Not accounted for in the annual agricultural returns	10,277,000 (27·7% of whole)	5,115,000 (26·8% of whole)	1,046,000 (31·2% of whole)	4,768,000 (28 0% of whole)

Figures exclude the Isle of Man and Channel Isles.

AGRICULTURAL STATISTICS OF THE BRITISH ISLES, 1950

	England and Wales	Scotland	Northern Ireland	Irish Republic
Area (as above)	37,132,000	19,069,000	3,333,000	17,024,000
Arable	13,950,000	3,210,000	1,196,000	3,759,000
Permanent grass	10,496,000	1,189,000	1,085,000	7,826,000
Rough grazing	5,470,000	10,924,000	708,000	not recorded
Not accounted for	7,216,000 (19·4%)	3,746,000 (19·6%)	344,000 (10·3%)	5,439,000 (31·9%)

productive farm land. The experience in the intensively cultivated countries of north-western Europe suggests that, with present systems of farming it takes about one acre to produce the food for one person on an adequate north-west European standard. On this basis, Britain can or should produce 55 per cent. of the food consumed or alternately can feed from home resources some 55 per cent. of the population. Actually the "target" of the post-war government in 1950–1953 was about 55 per cent. of the food consumed, leaving 45 per cent. to be imported.

These figures illustrate the extreme pressure on land in Britain and the need for land use planning.

The Land Utilisation Survey of Britain

Official statistics record acreage under certain types of land use, but do not permit the areas to be precisely located. Moreover, as the table above shows, more than a quarter of the whole country was left unexplained.

It was in order to map the distribution of different types of land use and to supplement the statistics collected by the Ministry of Agriculture that the Land Utilisation Survey of Britain was formed in 1930, and carried out a survey of the country in the years 1931 to 1939. The aim of the Survey, an organisation whose work was carried out by volunteers all over the country, was to show what use was being made of every single field in the whole of Great Britain.[1] The field work was done on the maps published by the Ordnance Survey on the scale of 6 inches to the mile, since these show the individual fields. The classification adopted by the Survey was drawn up so as to correspond as closely as possible with that used in the official statistics.

Description	Letter marking	Colour marking
(1) Forest and woodland	F	Dark green
(2) Meadowland and permanent grass	M	Light green
(3) Arable or tilled land, fallow, rotation grass, and market gardens	A	Brown
(4) Heathland, moorland, commons, and rough hill pasture	H	Yellow
(5) Gardens, allotments, etc.	G	Purple
(6) Orchards	O	Purple ruling
(7) Nurseries	N	Purple hatching
(8) Land agriculturally unproductive, *e.g.* buildings, yards, mines, cemeteries, etc.	W	Red
(9) Ponds, lakes, reservoirs, ditches, dykes, streams, and anything containing water	P	Blue

1. *Forest and Woodland.*—Woodland is marked on the one-inch maps and the six-inch maps published by the Ordnance Survey, and the character of the woodland is broadly indicated by symbols showing whether the trees are coniferous, deciduous or mixed, whilst other symbols indicate woodland of a scrubby nature. A classification of British woodland was drawn up by the Forestry Commissioners for the purpose of the Census of Woodlands taken in 1924, and this classification was adopted by the Land Utilisation Survey.

(*a*) *High Forest* (Fa) of trees which are being grown primarily for timber or which can be used for that purpose. When fully grown the trees in the high forest are sufficiently close for their crowns to touch. High forest can be divided into forests of conifers (Fa^c) and hardwoods (Fa^d) and of mixed conifers and hardwoods (Fa^m). The hardwoods are, of course, the ordinary deciduous trees, but the deciduous larch is included as one of the conifers.

(*b*) *Coppice* (Fb), or coppice with standards, woodland that is cut over every 10 or 15 years for fencing, posts, etc. The number of large trees or standards left varies, but they are not sufficiently close for the woodland to be called high forest.

[1] At a slightly later stage a similar survey was carried out in Northern Ireland under the direction of Mr. D. A. Hill and the results published.

(*c*) *Scrub* (Fc) consisting of small bushes or trees unfit for the production of timber.

(*d*) *Derelict Forest* (Fd) which has been cut or devastated.

2. *Meadowland or Pasture and Permanent Grassland.*—In the annual returns made by farmers or other occupiers of agricultural land a distinction is drawn between permanent grassland for mowing and permanent grassland used as pasture. Owing to changes in practice from year to year the distinction was not made by the Land Utilisation Survey, but the category of course excludes rotation grass —grass grown in rotation with crops.

3. *Arable, or tilled, land.*—In any one year land normally ploughed may fall into one of three divisions: that used for clover or rotation grasses, that occupied by crops, and that lying fallow. The three are included together in the maps of the Land Utilisation Survey.

4. *Heathland, moorland and rough hill pasture.*—This type of land is usually distinguished on the six-inch maps and in some cases on the one-inch maps. Swampy or reedy pastures and marshland which can be used as rough pasture have been included here by the Land Utilisation Survey. In the agricultural returns farmers make a return of this type of land, over which they have exclusive grazing rights, but only estimates are available of the areas where grazing rights are communal and of areas of similar character which are not actually used for grazing purposes.

5. *Gardens, allotments, etc.*—In the scheme drawn up by the Land Utilisation Survey houses with gardens sufficiently large to grow a few vegetables, or even flowers, are included in this category; but where there are only back yards or small areas which must be agriculturally unproductive, land used for housing falls into another category. Broadly the line is drawn where houses are fewer or more than 12 per acre. Allotments are to be regarded as gardens at a distance from the cultivator's house. Large private parks have been split up by the Land Utilisation Survey according to the actual use which is made of the land, much of it naturally being permanent pasture.

6–7. *Orchards* and *nurseries* have been separately shown on most of the published maps.

8. *Land agriculturally unproductive.*—This category includes buildings, yards, railways, mines, cemeteries, as well as waste land, *i.e.* all ground of which the soil is not productively used. On the maps of the Land Utilisation Survey, the difference between land in this category covered with buildings and land which is purely waste is readily apparent—except in the case of recent developments—because of the presence or absence of symbols for buildings.

It will thus be seen that the work of the Land Utilisation Survey was to show for the years 1931–1939 the exact use being made of

every portion of the surface. The bulk of the work refers to the years 1931–1935, only some of the remoter areas being covered at a later date and the whole was complete before the outbreak of war in September, 1939. The Survey has thus recorded the utilisation of land at a time which may well represent the *nadir* of British agriculture.

The material collected by the Survey has been published in several ways. The coloured 1-inch maps (with usually the same sheet lines and the same base maps, including water and contours, as the Popular Series of the Ordnance Survey though sometimes combining two sheets) which have been published total 168 sheets covering the more populous parts of Britain—the whole of England and the whole of Wales, and the South and Midland Valley of Scotland—as well as sample areas elsewhere. For the remainder of Scotland, the MSS. coloured 1-inch maps can be consulted. Finally, a generalised map on the scale of 1:625,000 or roughly 10 miles to 1 inch, in two sheets, covers the whole of Great Britain.

The details shown on the maps are analysed and the factors influencing present land use and its evolution are studied in detail in the series of county memoirs. This Report, under the title of *The Land of Britain*, has been issued in 92 parts, one for each county, the whole forming nine quarto volumes (1937–1946) to which a separate part covering the Channel Islands was added later. The main results have been summarised in my book *The Land of Britain: Its Use and Misuse* (London, Longmans, First Edition 1948, Second Edition 1950), which should be consulted on all matters relative to the use of Britain's land. In common with all the County reports, details are given of historical and economic aspects of land use and special attention is given to factors of permanent importance affecting town and country planning. When the present utilisation is compared with that in the past it is found that on the best and also on the poorest land there is considerable stability of land use

SUMMARY TABLE OF THE FINDINGS OF THE LAND UTILISATION SURVEY

	England		Wales		Isle of Man		Scotland		Great Britain	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Arable	8,339,400	26·0	535,900	10·5	65,500	46·5	3,128,600	16·4	12,069,400	21·4
Permanent grass	15,239,400	47·7	2,167,800	42·5	19,900	14·2	1,470,400	7·7	18,897,500	33·5
Orchards . .	257,100	0·8	3,400	0·1	—	—	800	—	261,300	0·5
Forest and wood	1,827,900	5·7	294,200	5·8	2,800	2·0	1,094,300	5·8	3,219,200	5·7
Rough grazing	3,812,700	11·9	1,906,400	37·4	44,800	31·6	13,011,300	68·2	18,775,200	33·3
Houses with gardens .	1,487,500	4 6	73,300	1·4	3,800	2·7	155,300	0 8	1,719,900	3·1
Agriculturally Unproductive	1,069,600	3·3	117,700	2·3	4,200	3·0	207,700	1·1	1,399,200	2·5
Total . .	32,033,600		5,098,700		141,000		19,068,400		56,341,700	

This table refers to conditions as they were before the plough-up campaign of the Second World War.

(except where housing or industrial development has taken place) but on land of intermediate quality economic factors have completely altered the type of utilisation in the last hundred years.

It is also clear, when viewed over the past century and a half, that the natural or geographical factors are of increasing importance.

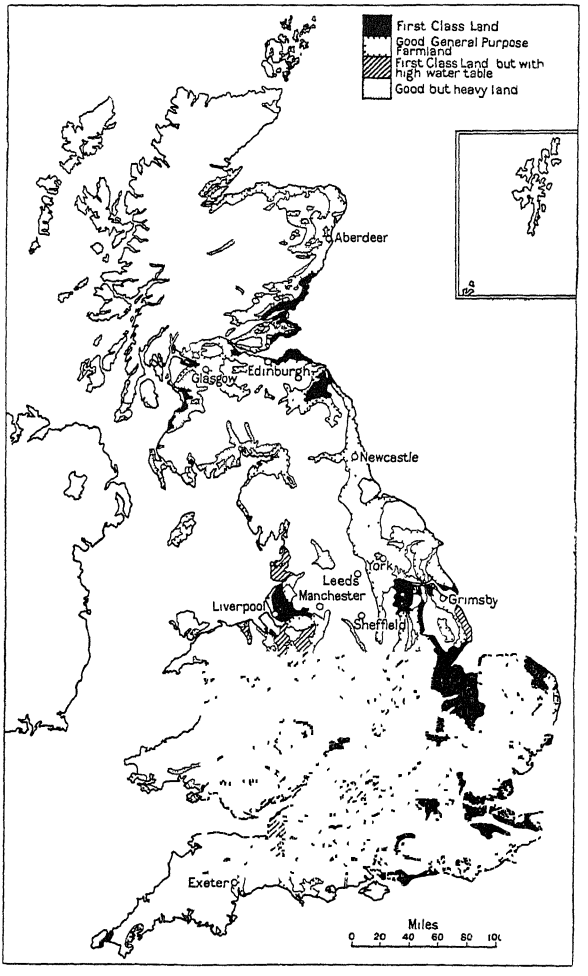

FIG. 86.—Map showing distribution of the good agricultural lands of Britain

Whereas in the past a country village, cut off by poor communications, had of necessity to grow most of its requirements and did so independently of the suitability or otherwise of local soils and other factors, at the present day conditions of soil and climate determine much more what is economically possible.

It is interesting though by no means easy to break down the large figure for houses with gardens including allotments and for land agriculturally unproductive. In 1936–1939 acreage of allotments was officially given as 122,600 acres in England and Wales, 4,100 in Scotland. In 1942 during the Grow More Food campaign of the war total increased to 179,000 acres. A rough estimate gave 457,240 acres occupied by roads (public highways with a total length of 179,630 miles in 1937–1938) and 250,000 acres for railway and railway yards.

The Classification of Land

When the British Government declared its policy of conserving good agricultural land wherever possible for food production, the classification of land assumed a major practical importance which has since been accentuated by the development of town and country planning. Under the Act of 1947 it is compulsory on every county and county borough to prepare development plans. Inherent land quality must not be compared with productivity, which may vary greatly under different forms of management but in a long settled country such as Britain present and past use usually affords a useful pointer to potential use.

A simple ten-fold classification into types of land was developed as a result of any work on the Land Utilisation Survey. It is described in detail in *The Land of Britain* and was reached after extensive discussion with the soil scientists. A map on the scale of 1:625,000 (Land Classification) is published in two sheets in the National Planning Series.

I Good	1(A)	First Class General Purpose Farm Land, capable of intensive cultivation, especially of vegetables, a food for direct human use.
	2(AG)	Good General Purpose Land, suitable for cash crop production.
	3(G)	First Quality Land, but with a high water table or liable to flooding.
	4(G)	Good Land, but heavy.
II Medium	5(AG)	Medium Quality Light Land, including Downland, Basic Grassland with certain areas suitable for arable cultivation (usually light land).
	6(AG)	Medium Quality, General Purpose Farmland, which is or can be productive whether under crops or grass.
III Poor	7(G)	Poor Quality Heavy Land.
	8(H)	Mountain Land, Mountain or Rough Hill Pastures.
	9(H)	Poor Quality Light Land (Lowland Heaths and Moors.
	10	Saltings, Rough Marsh Pasture, Wastelands, etc.

A, G, H, indicate suitability for arable, grassland, or heathland.

PROPORTIONS OF LAND OF DIFFERENT TYPES IN BRITAIN

	England and Wales	Scotland	Britain
I *Good*	*47·9*	*20·8*	*38·7*
1	5·3	2·1	4·2
2	26·0	10·1	20·6
3	3·3	—	2·2
4	13·3	8·6	11·7
II *Medium*	*32·0*	*15·1*	*26·3*
5	7·0	0·4	4·8
6	25·0	14·7	21·5
III *Poor*	*17·0*	*63·5*	*32·8*
7	2·2	0·3	1·6
8	12·1	62·9	29·3
9	2·2	0·3	1·5
10	0·5	0·0	0·4
Residue—Built over, etc.	3·1	0·6	2·2

The total area of First Class Land (1) is thus only 2,359,900 in the whole of Britain, but the proportion of good land is high at 21,809,200 acres.

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CHAPTER VIII

THE NATURAL VEGETATION OF BRITAIN[1]

IT is frequently stated that except for areas of fenland and marsh the natural vegetation of the whole of the British Isles was forest or woodland, and the small extent of woodland at present remaining —only about 5 per cent. of the surface of the whole country— is frequently quoted as evidence of the extent to which man has cleared the natural vegetation of the country and artificially altered the appearance of the surface. Whilst it is perfectly true to say that natural woodland has been cleared over vast areas—as, for example, over the Weald of Kent, Surrey, and Sussex—it may be that there is a tendency to exaggerate the former extent of forest land in the British Isles as a whole, and to ignore other types of natural vegetation. Further, when one is discussing the former extent of natural vegetation it is necessary to say exactly to what period one is referring. Before dealing with the different types of vegetation which may be found in the country at present, it will be useful to outline the changes which one may postulate as having taken place since the close of the great Ice Age.

It has already been pointed out that during the great Ice Age ice sheets covered Britain as far south approximately as a line joining the Thames and Severn, and also the whole of Ireland with the exception possibly of certain tracts in the south. Whatever may have been the pre-glacial vegetation of the British Isles, it is clear that the conditions prevailing in the south of both Britain and Ireland at the time of the maximum extension of the ice sheet (the Second Glacial, cf. p. 134) must have been the conditions of the Tundra lands. With the final retreat of the ice after the Fourth Glacial and the amelioration of climatic conditions Britain was gradually re-colonised by plant species from the Continent, that is from the south and east. Indeed, there are numerous species still restricted to the south and east, and on the whole the flora of the British Isles becomes poorer in species as one goes northwards and westwards. Just as in northern Russia and Finland at the present day, to the south of the Tundra Belt the dominant trees of the great forests are birch and pine, so we have good evidence that as the ice finally receded in Britain these were the first trees to invade the country. The

[1] The authors are greatly indebted to Sir E. J. Salisbury, F.R.S , for valued criticism and advice on the original draft of this chapter.

analysis of pollen in the successive layers in peat deposits—work associated especially with the name of Dr. H. Godwin—has enabled an exact sequence to be worked out and this is summarised in the accompanying table.

CHRONOLOGY OF THE GREAT ICE AGE AND AFTER

	Climate and Ice Conditions	*Human remains and cultures*	*Important events and deposits in Britain*
Post-Glacial	Sub-Atlantic Atlantic (wet, mild) [sudden change] Boreal (dry: cold winters, warm summers) Pre-Boreal (dry, cold) Sub-Arctic	Historic Times Iron Age Bronze Age Neolithic (New Stone Age: polished implements)	VIII Alder-Oak-Elm Birch (Beech) Zone of Godwin VII Alder-Oak-Elm-Lime Zone Final cutting of the Strait of Dover VI Pine-Hazel Zone } submerged forests V Pine Zone Steppe Animals IV Birch-Pine Zone Tundra conditions Many glacial lakes
Fourth Glacial	Lake District and other mountain regions with valley glaciers	Magdalenian (Creswell Cave Man) Aurignacian	York Moraine Last Coombe rock formed in south Ponder's End Arctic Plant Bed
Third Inter-Glacial		(*Homo sapiens*)	? Buried Channel of Thames Flood Plain Terrace of Thames
Third Glacial	Little Eastern Glacier: Irish Sea Ice	"Cave" Man (*Homo neandertalensis*) Mousterian implements	Newer Drift. Cromer Moraine Coombe rock (glacial sludge) formed in south
Second Inter-Glacial	Long Warm Period	Acheulian implements	Taplow (50-foot) Thames Terrace, covered with loess or brick-earth. Mammoth Swanscombe (100-foot) or Iver-Boyn Thames Terrace with warm water molluscs and southern mammals
Second Glacial	Maximum Glaciation	Chellean implements	Ice-sheet nearly as far south as London Deposition of Older Drift (including Chalky Boulder Clay of East Anglia)
First Inter-Glacial			
First Glacial	North Sea (Scandinavian) Ice-Sheet	Pre-Chellean	Norwich brick-earth of north-east Norfolk
Pre-Glacial		*Eoanthropus*	Pre-Glacial Raised Beach of the south-west

"River Drift" Man

After the early post-glacial birch-pine forests (Zone IV of Godwin) pine became dominant (Zone V), then pine with hazel (Zone VI).

This was throughout a period with dry cold winters (the Boreal Period) and Britain was probably still joined to the Continent and was inhabited by Neolithic man—using polished stone implements. The submerged forests round the coasts of Britain are largely of this age. There seems then to have been quite a sudden change to wet, mild conditions (the Atlantic Period) which may be due to the final severance of Britain from the Continent and the establishment of the present system of oceanic circulation. The change was marked, probably about 4000 B.C., by a great development of oak not in association with elder, elm, and lime (Zone VII) and later with elder, elm, birch, and beech (Zone VIII) during which times Neolithic culture gave place to Bronze Age and then Iron Age man.

It is still uncertain how far north some of the invading trees and other vegetation extended, but in Iron Age times, shortly before the Roman invasion and the Christian era, we can thus picture the British Isles as for the most part forest-covered, the types of forest present being determined by climate and by soil, and ranging from forest in the north in which the Scots pine and birch were dominant to the great stretches of oak woodlands on damp soil in the Midlands and south, and to the beech and hornbeam forests of the drier areas in the south. The forest cover may, however, have been interrupted over wide tracts by other types of natural vegetation. Fenland and fresh-water marshland probably covered very large areas, such as in the region still known as the Fens, of which a description will be given later. Proofs exist that much of the heathland and moorland of the present day was formerly forested, but this may not apply to the whole of the great areas that are now moorland. Scrubland, which can be defined as the transition phase between grassland or heathland and forest, may also have covered very considerable areas. It is much more difficult to assess how far grassland may be regarded as a natural type of vegetation in Britain. At present there are three or four kinds of grassland which correspond broadly with the main types of forest. Thus the chalk or fescue grassland which is characteristic of the shallow soils derived from the chalk corresponds with the beech forests found on the same soils. These chalk grasslands may have been typical sheep pastures from very early times, whilst more recently the ravages of rabbits and other small grass-eating animals have contributed to prevent the growth of forest on these upland tracts.

It may have been the more open character of the vegetation on the higher limestone tracts made them attractive to the Neolithic settlers. There is no doubt that the Neolithic settlements occurred in such areas, and early Neolithic roads are found for the most part on such elevated tracts, despite difficulties of an adequate water supply (see Chap. XXIV). Another type of grassland, often called grass heath, occurs on sandy soils and shows many transitions to and

from heath proper. A third and very common type of grassland is that which is called neutral grassland, and which corresponds to the oak forests of the heavy clay lands. This on alluvial soils, or where the water level is high, passes naturally into waterside meadow, corresponding broadly with the willow and alder woodlands.

There can, however, be little doubt that most of the grassland of the present day owes it character to human influence.

An attempt will now be made to describe very briefly some of the more important types of the natural and semi-natural vegetation which are found at the present day in the British Isles. Before doing so it will be well to understand the principle involved in plant succession. Each type of physical environment, that is each combination of climate, soil, etc., may be regarded as having an association of plants peculiar to itself, and this plant association would form the natural vegetation cover, provided interfering factors are absent. This natural vegetation association is known as the climax association, but it must not be supposed that a tract of country such as Britain must have been when the ice sheet left it, or a tract of land which has been cultivated by man and then deserted, will immediately become covered with the climax vegetation. It is instead invaded and colonised by plants whose dominance is limited in that they will in time become ousted by others until the climax community eventually establishes itself. Thus the natural vegetation cover passes through a succession of stages; owing to the depredations of animals such as rabbits, the interference of man and his domestic animals, certain of the stages in the plant succession may become quasi-permanent and the climatic climax may not have an opportunity of establishing itself at all.[1] Thus in attempting to describe the natural vegetation cover of the British Isles we shall be dealing with various stages in the plant succession as well as climax communities.

Referring to the table given on p. 124, showing the utilisation of the surface of the British Isles, we may regard natural and semi-natural vegetation as embracing the first two categories—namely, the woods and the rough grazing land, which broadly speaking is moorland and heathland, and at least to some extent the permanent pasture—whilst under the heading of other lands are included certain areas of marsh, etc., which are definitely natural vegetation.

TYPES OF NATURAL VEGETATION

The following brief account of the chief types of natural vegetation found in the British Isles has been based in part upon the standard work on the subject, *The British Islands and their Vegetation*,

[1] Reference should be made to the important studies by Dr. E. Wyllie Fenton, *The Influence of Man and Animals on the Vegetation of Certain Hill Grazings in South-East Scotland*, Edinburgh School of Agriculture, I and II. 1951–1952.

by A. G. Tansley.[1] The types have been arranged in the following summary under the three broad headings of forest and woodland, heathland and moorland, and grassland, and thus correspond with three main categories which have been distinguished in the maps of the Land Utilisation Survey of Britain. Thus the types described under the forest and woodland will include the principal types of natural vegetation to be found in those areas coloured dark green on the Land Utilisation maps. Similarly the type described under heathland and moorland will be the types which make up the areas of yellow colour on the map, whilst the types described under grassland will be those which correspond to the light green areas on the Utilisation maps.

I. Forest and Woodland

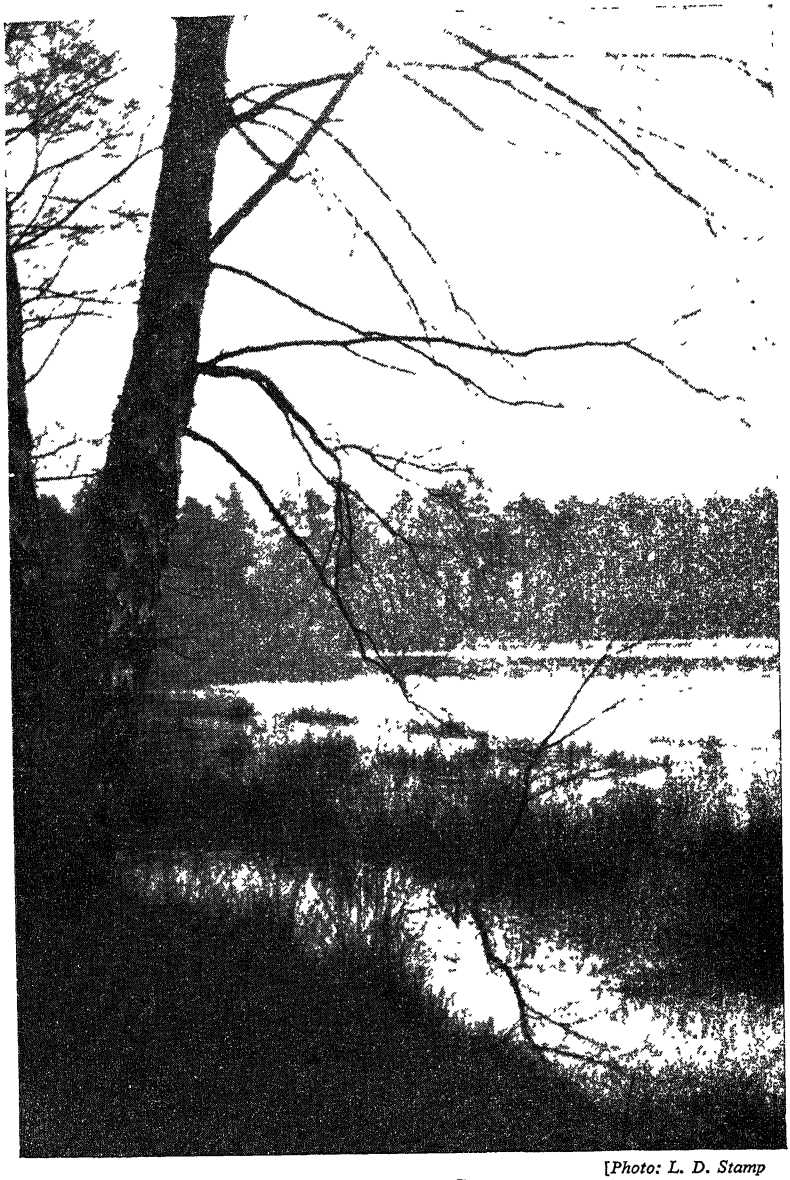
(1) *Damp Oakwood or Pedunculate Oakwood.*—In more ways than one the oak is the characteristic British tree, and there can be little doubt that the whole of the lowlands of Britain with clayey or loamy soils were at one time covered with oak forests. Most of the woods still existing on these soils, with the exception of those, of course, planted with exotic species, are also oakwoods or derived from oakwoods. The dominant tree on the heavier soils and those well supplied with mineral salts is *Quercus robur* (*Quercus pedunculata*), or the pedunculate oak. Most of the British oakwoods have been heavily exploited for timber in the past.[2] Oak was in special demand for shipbuilding before the extensive use of iron and steel. The rise of the English Navy and Mercantile Marine coincided with a rapid using up of extensive oak forests, particularly in the south-east of England, where the oak forests were within easy reach of navigable waters and harbours. During the Middle Ages, too, when most of the iron was smelted by means of charcoal, there was an enormous destruction of oak forests. It is of course well known, as explained elsewhere in this book, that the disappearance of the Wealden iron industry was not due to the exhaustion of the ore, but to the virtual exhaustion of the supply of wood for charcoal. Most of the oakwoods which remain have been sadly neglected from the forestry standpoint and really good standard trees, suitable for the production of timber, are few. In the south and midlands of England the majority of oakwoods are now in the form of coppice with standards. That is to say there are some eight to a dozen

[1] First published in 1939, this magnificent work summarises much of the research published in the *Journal of Ecology*. It replaces the earlier work *Types of British Vegetation* (1911), which was edited by Tansley. A Second Edition of *The British Islands and their Vegetation*, split into two volumes, appeared in 1949.

[2] Primitive woodland can frequently be distinguished even from very old plantations by a greater richness in plant species of the ground vegetation.

"standards" or large trees per acre, whilst the intervening area is occupied by "coppice," trees of other species. By far the most common of coppice trees is hazel. The tree is cut near the ground and the stump sends up a number of shoots. After a period of ten or fifteen years the main branches thus formed are cut for the provision of fencing posts, etc., the smaller ends having a small market as bean sticks and pea sticks. Ash and birch are also common in coppice woods, and oak itself may be coppiced, in addition to the oaks which grow as the standard tree. Another important coppice tree is the Spanish chestnut, much favoured for fencing because it splits evenly into two half-round sections. It is urged by some that these woodlands of coppice with standards are legacies from the Middle Ages when the oak woods were thinned in such a way that the remaining trees branched freely and thus gave a supply of curved timber and "knee" pieces which were particularly useful in shipbuilding; obviously quite contrary to the usual requirements of modern industry of good straight timber. The copse or coppice with standards will obviously present a very different appearance shortly after it has been cut, and a recently cut woodland is usually characterised by a rich growth of ground plants, including the favourite primrose and bluebell. These almost disappear as the coppice trees once more grow up and cast a greater shade over the ground. The wood anemone and dog mercury are other characteristic ground plants. "On the edges of burnt oakwoods which have been carelessly exploited a scattered scrub is commonly found with spaces of turf between the clumps of bushes and an occasional isolated oak tree. This vegetation represents degenerate oakwood from which the trees have nearly all quite disappeared." Many of the species present in this scrub are spiny species, and this is doubtless due to the fact that they are protected by their spines from browsing animals. This kind of land is occasionally used for pasturing, but has economically no value as woodland (recorded by the Land Utilisation Survey as Fc).

(2) *Dry Oakwood.*—Oakwoods also occur on dry sandy soils. The oak may either be *Quercus robur* or *Quercus sessiliflora*, or the two may be mixed. Birch is usually found in the dry oakwoods in varying proportions, but the hazel and the ash are usually absent. The ground vegetation is usually poor, but a common feature is the presence of large quantities of bracken. The beech may occur, particularly in societies or clumps, and as usual in beechwoods the undergrowth is here almost absent. Scrub may occur on the margins of these dry oakwoods, and the woods, especially oak with birch, often grade insensibly into heathland. As Tansley points out in his later writings there is no fundamental difference between damp and dry oakwoods. Reference will be made later to the oak-birch heath.



[*Photo: L. D. Stamp*

FIG. 87.—A Surrey Common

Birch-heathland, with sub-spontaneous pinewoods in the background—a view taken a hundred yards from a main road within twenty miles of London

(3) *Sessile Oakwoods* (Durmast Oakwoods).—On the older rocks of the British Isles, which, as already described, furnish poor siliceous soils, oakwoods again occur, but here the dominant tree is the

Durmast oak, *Quercus sessiliflora*. The soils are shallow and are usually deficient in soluble salts, especially calcium, and often show a marked tendency to allow the accumulation of acid humus. Durmast oakwoods occur, however, on a great variety of soils, but always with soils poor in mineral salts. The trees are therefore on the whole of small dimensions; where larger, the trees are of a more upright habit[1] than *Q. robur*. The birch (*Betula tomentosa*) commonly occurs, the beech is sometimes found in larger woods. Conifers are not indigenous, but both the larch and the Scots pine are commonly planted. The holly (*Ilex aquifolium*) is usually found in the oakwoods on the Pennines. On the hills such as the Pennines and in Wales, it would seem that these oakwoods formerly extended to higher levels than at the present day. They tend to degenerate now into scrubland and there is every passage from scrub to grassland and moorland. In the intermediate stages, especially on the drier soils, bilberry and bracken are very common. In the Pennines and drier regions the ash is usually confined to wetter situations and the sides of streams, but in the regions of the British Isles which have a heavy rainfall, for example in the Lake District, most of the oakwoods contain a very large proportion of ash, and one really has an oak-ash woodland. The same is true, for example, of some of the Devonshire woods.

(4) *Birchwoods*.—Anyone who knows the great northern forests of Russia and Lapland will know the extent to which the birch is there intermingled with hardy coniferous trees. It is not, therefore, surprising to find a fringe of birchwood occurring above oakwoods in the British Isles, and forming in the Highlands of Scotland characteristic woods at the sides of the valleys, sometimes even occurring up to elevations of 2,000 feet. The birch is a light demander, but can stand great exposure. Because Scots pine thrives with much the same conditions, birchwoods and pinewoods are largely interchangeable. Oakwoods from which the oak has been removed are often replaced by the less valuable birches and become birchwoods, whilst wood clearings often seen to pass into birchwoods rather than back to the original oakwoods. Thus the birchwoods may replace the oakwoods or may occur definitely as a vegetation layer above them.[2]

(5) *Pinewoods*.—Although the Scots pine (*Pinus sylvestris*) was formerly native in many parts of England and Ireland, it is generally agreed that it disappeared from the south of England, and has only recently been reintroduced (in the eighteenth century or perhaps

[1] These oakwoods may be coppiced on a twenty-year rotation.

[2] It has been pointed out by Sir E. J. Salisbury that primitive man, working with stone tools, would find the birch easier to cut down than oak, and it may be that he was attracted to higher ground in many parts of Britain not because the ground was already clear but because the birch forest was more easily cleared.

earlier). In Scotland pinewoods at one time covered large areas in the broad valleys or straths of the Highlands and the glens, extending for considerable distances up the mountain slopes. Owing to heavy exploitation the area occupied by these pine woodlands is now rather seriously restricted. On its introduction into the south of England the Scots pine spread very rapidly over tracts of sandy soil, and it now forms extensive sub-spontaneous woodland, as on the Bagshot Sands of the London Basin and on the Lower Greensand of the Weald. But whether in Scotland or in the south of England, there is a very close association between pinewoods and heathlands, and it is often difficult to decide whether an area should be classified as a pinewood, or as heathland with many scattered pines. It will be seen that on the dry soils of the south these pinewoods are competitors with dry oakwoods and with beechwoods. The close pinewoods are very poor in other species, partly on account of the deep shade and partly because of the thick layer of pine needles which carpets the floor of the woods. Where more open, bracken is common, whilst over large areas the bilberry (*Vaccinium myrtillus*), as in the great coniferous forests of the north of Europe, is very characteristic, associated of course with the heath (*Calluna vulgaris*).

(6) *Beechwoods.*—By pollen analysis Godwin has now proved that the beech (*Fagus sylvaticus*) invaded Britain in Atlantic times, but afterwards it retreated from the south-west and elsewhere. Because it only behaves as a native in the south-east it was long thought to be a recent introduction. Beechwoods occur characteristically on the chalk, occupying the steep valley sides or the scarp faces on the North and South Downs as well as large areas in the Chiltern Hills and in parts of the Cotswolds. They are absent from the northern chalk areas of Yorkshire and Lincolnshire as well as of Norfolk. On the Continent the beech tends to occur rather on the marly or damper limestone soils. In England the beech is natural to the drier limestone soils, possibly as a result of the generally damper character of the English climate. The way in which the beechwoods occur on the steep sides of the chalk valleys has given rise to the commonly applied name of "hanger" for this type of wood. The beech is not only the dominant tree in the beechwoods, it is very frequently the only tree, and indeed typically forms pure high forest in close canopy. Shrubs and ground vegetation are scarce, in fact the latter is often quite absent, and the ground covered with nothing but the delightfully brown fallen leaves. Thus, walking through a beechwood, there are many characteristic points of difference to be noticed from other types of English woodland. Occasionally the yew occurs as a shrub in the beechwood forest, and locally the yew has become dominant and forms yew-woods. Beechwoods are not restricted to the chalk; the beech has migrated to lighter sandy soils, much more rarely is it found

on heavier clay soils. It is essential that there should be free drainage round the roots. The beech cannot grow with its "feet in water."

(7) *Ashwoods.*—Ashwoods are characteristic of limestone soils in the north and west of England, where, as already pointed out, beechwoods are absent. They are thus well-known features of the limestone dales of the Carboniferous Limestone of Derbyshire and of the Mendips. Wych elms are commonly found in these ash-woods whilst shrubs are characteristically abundant (including a number of species), partly owing to the high light intensity, even in summer, resulting from the translucent canopy of the trees. On marly soils the oak becomes important and one may really distinguish an ash-oak woodland association as characteristic of marls and calcareous sandstones. Again, hazel is common, and where the oaks have been left as standards one may have an ash-oak-hazel coppice, very common indeed in the south of England, especially towards the rather damper west, taking the place of the oak-hazel coppice, which occurs on clay soils which are poor in lime.

(8) *Alder-willow associations.*—The alder (*Alnus rotundifolia*) and the willows (*Salix*) are the characteristic trees of very damp situations. By the sides of streams in oakwoods the alder usually appears, whilst the alder-willow association is the woodland association which corresponds to marshland.[1] The osier (*Salix viminalis*) is of course usually planted—on tracts of alluvium by the sides of rivers where the surface of the ground is only a few inches above the permanent water level. The ground vegetation in such situations is that of a typical marsh. In the wet areas of East Anglia the woodland formation, occurring associated with fens, is known as swamp carr and marsh carr.

II. Heathland and Moorland

Under the title of Rough Grazing, Mountain Heath, Moor or Downland, the published statistics of the Ministry of Agriculture and Fisheries include a considerable variety of types of natural vegetation. This category is identical with the Heathland, Moorland, Commons, and Rough Hill Pasture distinguished by the Land Utilisation Survey of Britain and shown on their maps in yellow.

In 1940 Sir George Stapledon and Mr. William Davies extended to England a reconnaissance survey they had previously carried out in Wales and later a map on the scale of 1:625,000 was published and is usually referred to as the Grassland Map. It shows, highly

[1] Sir E. J. Salisbury believes that alder woodland was formerly very widespread in low, damp ground, but, because of the relative ease with which the alder could be cleared by primitive man with stone tools, was largely destroyed at an early date. Compare the early settlements on valley gravels (see p. 585) where the lowland water-side meadows were an added attraction.

generalised and ignoring both woodland and ploughland, lowland grassland divided into eight categories according to agricultural quality. The heathland, moorland and rough pasture are shown divided into eleven types:—heather moor, heather fell (i.e. with many boulders) lowland heaths; cotton grass and deer-grass moors, molinia moor and nardus moor; mountain or hill pastures and grassland invaded by bracken, gorse, etc; basic pastures of mountains, downland, and lowland grass heaths.

This scheme was extended and enlarged for use in Scotland and a map prepared using existing data which was published in *The Land of Britain: Its Use and Misuse*, Fig. 90, p. 151.

It will be found that these schemes agree generally with that given below, based on Tansley.

(1) *Heathland or Heath Associations.*—In heathland by far the most widespread and abundant species is ling or heather (*Calluna vulgaris*). With it are usually associated other members of the Ericaceæ of which *Erica tetralix* is one of the commonest; whilst towards the north of Britain the bilberry (*Vaccinium myrtillus*) becomes dominant over considerable tracts. Under the dense shade of *Calluna* very few other species can exist. Heathland is usually found on gravelly or relatively coarse sandy soil, or on similar soils derived from the older rocks in the north. The coarse, gravelly or sandy soil usually has a dark surface layer coloured by much humus, below which there is a layer of leached sand, often pale-grey, or even whitish in colour. Between this and the unaltered sands below there is frequently a compact stratum of hard moorpan. The moorpan may be only a few inches but perhaps several feet below the surface, but it is this which prevents the invasion of heathland by trees, and heathland in which the hard pan is present cannot be afforested unless the pan is broken up or holes made in it for the roots of young trees to penetrate. Thus the heath association is usually a stable association, either resulting from the final degeneration of the oak-birch-heath association or a stage in the succession on poorer sandy soils. Where the hard pan is absent there may be every gradation from the pure heathland to the oak-birch association, or to pinewood. It is frequently difficult in studying a tract of country to decide what should be called pinewood with a ground vegetation of heather and heathland with scattered pine trees. Indeed any distinction must be a very artificial one. Gorse is often found on the margins of heathland where conditions are less acid, though it is not essentially a typical member of the heathland itself. Local bogs are common in heathland. Some of the better known regions of English heathland include the stretches of flat sandy country in north-west Norfolk, and south-east Suffolk on the crags or on the more sandy members of the overlying drift deposits. Heaths are well developed on the Bagshot Beds of the

London Basin, and on the sandy Tertiary beds of the Hampshire Basin. They are common, too, on the sandy beds which occur in the Wealden area. Both the sandy soils of the New Forest region and the sandy soils of the Weald afford an excellent example of the way in which heathland dovetails into the oak-birch woodland and pinewood. In the west heathland occurs both on Devonian Sandstones, as on Exmoor, or on the granite masses, such as Dartmoor. Here, being in the wetter part of the country, there is frequently a gradation into true moorland with heather growing on peat. In Yorkshire the name "moor" is often applied to true heathland, and here varieties have been distinguished according to the dampness of the areas. Heathland in Scotland does not usually occur at greater elevations than 2,000 feet, and is found in those parts of the Highlands where the mean annual rainfall is comparatively low—less than 60 inches. The heathlands of the Highlands are usually called moors, and are indeed the typical grouse moors. As such they are systematically burned in rotation every ten to fifteen years. In various regions, the association of bracken with typical heathland should be noticed. Bracken usually indicates a relatively good soil.

(2) *Limestone Heathland.*—In the ordinary way heather is a plant that dislikes lime, and it is not therefore found on calcareous soils. But some plateau areas of limestone, owing to leaching action, tend to lose their lime, and consequently in such areas heather may occur, but it is associated with plants which have long roots, and which therefore reach the limestone below and are thus lime lovers. This accounts for some heath-like vegetation occurring in limestone areas. Of rather a different order are the limestone pavements which occur as striking features on some of the summits of the Carboniferous Limestones, as in the north Pennines and in the great limestone plain of County Clare in western Ireland. The exposed surface of the rock is very bare, and although rather rich in mosses it is extremely poor as regards larger plants which are more or less restricted to crevices. Heather (*Calluna*), though a calcifuge, may be present partly because of the existence of little pockets of soil from which the lime has been leached.

(3) *Moorland.*—Moorland is a comprehensive term, and includes many different types of natural vegetation. Moorland is essentially the vegetation of peaty soils. Frequently the soil is deep, practically pure peat; in other cases there is only a shallow layer of surface peat much mixed with mineral substances from the underlying rocks, in which case there is naturally a transition stage between the moorland and heathland, as one finds in the "moors" of the North Riding of Yorkshire. There are also peat soils, especially those relatively rich in lime (hence called mild peat) and developed particularly, as far as Britain is concerned, in East Anglia, to which the name black fen is frequently applied. Separating moor and fen,

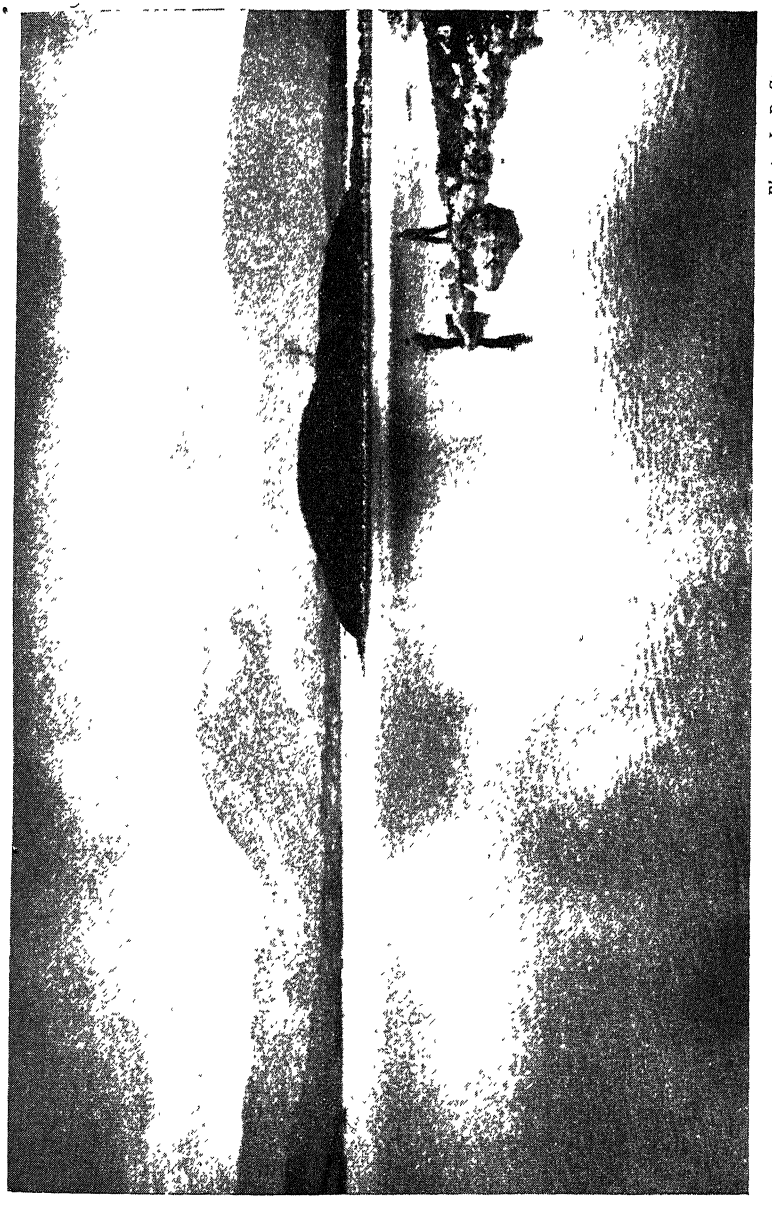


Photo L D Stamp

FIG. 88.—The Moor of Rannoch, Argyllshire, Scotland

Showing one of the innumerable small lochs. The hills (part of the Grampians) in the distance are covered with *Scirpus*moor and Heathermoor

moor has a relatively wet peat soil of considerable depth, fed by water poor in mineral salts, suffering from lack of aeration so that the humic acids produced give rise to a soil water which is acid in reaction. Fen, on the other hand, has a peat or peaty soil fed by water which is relatively rich in mineral salts, with the result that the ground water is alkaline in reaction. When drained, the peaty soil of the fens gives rise to a very dark coloured but extremely rich soil; whereas even when drained it is difficult to carry out cultivation on many tracts of moorland because of the essentially acid nature of the soil. In moorland a broad distinction is possible between lowland moors, such as those areas known as "mosses" in Lancashire, and upland moors. *Sphagnum* is a very common constituent of lowland moors and in the valley moors which occur in the south of England in the wetter parts of heathland. Amongst the different types of upland moor which have been distinguished in the wettest areas there is the *Sphagnum*, or bog moss moor, of comparatively limited extent. The cotton grass moors are characterised by the cotton grass (*Eriophorum vaginatum*) and are much more extensive in their occurrence. Cotton grass moors are widely distributed on the summit plateau of the Pennines, and sections through the peat of these areas show that considerable areas of these moorlands were once forested. *Scirpus* or reed moors occur in the wetter regions of the north-west Highlands of Scotland, as well as in some parts of Ireland, such as the Wicklow Mountains. The dominant plant is *Scirpus cæspitosus* with often a considerable quantity of heather. There is evidence that some of these moors, too, were formerly forested, the remains of Scots pine and birch having been found in the peat.

(4) *Bilberry Moors.*—The dominant plant here is *Vaccinium myrtillus* (the bilberry) and this type is common in the Pennines and in the central part of the Highlands of Scotland, but not in the north-west nor the Hebrides.

(5) *Heather Moors.*—These differ from the heathland mainly in the occurrence of a greater thickness of peat, and the frequent association of heather and cotton grass or heather and bilberry.

(6) *Grass Moorland.*—Grass moorlands cover large areas of Boulder Clay, such as in the southern part of the Southern Uplands, and also in the western Highlands of Scotland. The grass moorland tends to be intermediate in character between the *Scirpus* moor, already described, and siliceous grassland. The vegetation is mainly composed of a variety of grasses, rushes, and sedges, but as in other moors, the soil is peaty, acid, and generally wet during most of the year.

III. Grassland

Five or six main types of grassland may be distinguished and may be regarded as semi-natural formations in that they correspond

with different types of woodland, and are found where the woodland has been cleared.

(1) *Neutral grassland.*—The adjective "neutral" indicates that the soil of these grasslands is neither very acid on the one hand nor particularly calcareous on the other. The neutral grassland is the ultimate phase of degeneration of damp oakwood and so occurs associated with damp oakwood on the same types of soil. It consists of a close turf of grasses with associated herbaceous plants. The plants characteristic of calcareous pasture on the one hand are absent, and so are those which are characteristic of heath pastures. Neutral grassland affords excellent permanent pasture and is usually heavily grazed, but where less heavily grazed, as on the borders of some of the village greens of central and southern England, has many of the plants common to the ground flora of the damp oakwoods, including the anemone and the primrose. Where clay soils are low lying, and ground water approaches the surface, the appearance of various species of rush (*Juncus*) may be noticed in neutral grasslands and marks a gradual passage towards rough marsh pasture. The line is often very difficult to draw, and this was found to be the case in surveying for the Land Utilisation Survey. The best neutral grasslands are the permanent pastures dominated by rye grass (*Lolium perenne*) and wild white clover (*Trifolium repens*).

(2) *Acidic grasslands.*—Grassland dominated by bents (*Agrostis* spp.) together with sheep's and red fescue (*Festuca ovina* and F. *rubra*) probably covers a greater area than any other type of grassland in Britain. It is the typical community of the "grassheath" and "siliceous grassland" of earlier writers. Grass heath is associated with dry oakwood. Although transitions to ordinary heath are found, in the grass heath true heath plants, such as *Calluna*, *Erica*, etc., may be, and usually are, entirely lacking; but the grasses are those which prefer a sandy soil and usually form a close short turf. These grasslands are less valuable as grazing lands than the neutral grasslands, and so one often finds patches of gorse coming in on the margins of such areas. The East Anglian "heaths" sometimes include quite considerable stretches of dry grassland of this character, and it is believed by some writers that they represent a survival of steppe, or semi-steppeland, conditions in Britain. The better "siliceous grasslands" correspond with the sessile oakwoods which occur on the thin soils of the older rocks. In such areas as the Pennines they tend to occur, not only associated with the oakwoods, but at higher levels.

(3) *Nardus and Molinia moors.*—On land with poorer soils or more acid conditions, grassland gives place to what is better described as moorland although dominated by grasses. On poorer drier areas the characteristic grass is the mat grass (*Nardus stricta*); whilst on the wetter soils the purple moor grass (*Molinia cærulea*) is the

characteristic grass. In the south-west, the characteristic grass is *Agrostis setacea.* The dominance of grass is sometimes interrupted by stretches of bracken, whilst the small gorse comes in abundantly in such areas as the Malvern Hills, Devon, and some of the hilly areas of Ireland. In wet areas rushes appear.

(4) *Limestone or Basic grasslands.*—The springy turf that is characteristic of the chalk downs is almost proverbial; it is commonly referred to as downland. Similar grassland is found on other limestones in this country notably on the Jurassic limestones of the Cotswolds and a somewhat similar associating plant reappears on some basic igneous rocks. The grasses of the siliceous grasslands are absent, and the bracken, the gorse, and the rushes are on the whole uncommon. The heaths, too, are practically unknown. No one who is familiar with the delightful chalk downlands in the south of England will need to be reminded of the characteristic herbaceous flora, with numerous flowering herbs peculiar to itself, including many of our orchids. Generally the dominant grass is the red fescue (*Festuca rubra*) or sheep's fescue (*F. ovina*). Although a great proportion of the chalk pastures in England are old, it is going too far to say that the area has never been occupied by woodland. The chalk and limestone grasslands have, of course, long been famous as sheep pastures. Rabbits also are very abundant, and where they do occur in numbers the turf is even more closely nibbled than by the sheep. The fescue, with its wiry herbage, is very largely responsible for the springy nature of the turf, which is thus so delightful for walking.

(5) *Arctic-Alpine grasslands* and *Mountain Vegetation.*—Arctic-Alpine grassland is practically restricted to the higher levels in the Highlands of Scotland. The grasses and other plants tend to have a rosette habit, and naturally the species occurring are of particular interest in view of what has been said above as to the possible origin of this vegetation. This, with certain very wet types of grassland, may be the only type of truly *natural* grassland in Britain.

IV. Fenland and Fresh-water Marshland

The vegetation of fens, fresh-water marshes, mosses and bogs is ecologically very interesting but economically unimportant. Some very reedy pastures are intermediate in character and can be used for rough grazing, but the true fen and fresh-water marsh are of little use except for the yield of rushes for such purposes as thatching.

V. Salt marsh

The vegetation of regions which are characterised by the presence of salt in the soil or which are periodically flooded by salt water, whether under the influence of the tide or occasionally, consists of plants specially adapted to withstand these curious conditions,

and known as halophytes. They are commonly fleshy plants of which the glassworts (*Salicornia*) are particularly characteristic. Some of the drier types of salt marsh can be used for occasional pasture. The numerous types of salt marsh are of particular interest to the ecologist, but are rather outside the scope of the present work. Those plants which bind and hold marine muds and enable land to be reclaimed are clearly of economic importance. Of these *Spartina townsendii* has colonised large areas in the south of England.

VI. Sea Coast and Sand-dune Vegetation

Hard, wiry grasses are characteristic of the vegetation of young sand-dunes. Some of them are particularly valuable because of their ability to bind sand-dunes and prevent their movement over valuable land. The sea couch grass (*Agropyrum junceum*) and the marram or star grass (*Ammophila arundinacea*) are specially interesting in this connection. Occasionally a few goats find pasturage on sand-dune grasses, and there is quite a considerable use of older dunes as golf courses. The study of grasses suitable for planting as greens for the golf courses is thus a matter of some general interest.

It might be thought that the study of the natural and semi-natural vegetation of the British Isles has comparatively little practical importance. This, however, is very far from being the case. The natural vegetation of an area, in fact, forms a perfect index of the sum total of conditions, particularly of soil and climate, which affect the growth of any plants which may be introduced by man. For example, in introducing foreign species of trees for afforestation experiments in Britain it may be essential that they should be introduced in regions where the environment corresponds with the environment where they are found to flourish in their own home localities. The character of such environment in this country can be gauged by the natural vegetation ordinarily existing though some exotic species when introduced are found to require conditions here different from those of their homeland. Further, a detailed study of the natural vegetation existing, for example, in our moorland tracts, is an indication as to what is wrong with the soil from the point of view of its further utilisation in other directions, *e.g.* in agriculture. The presence of reeds in ordinary meadows is definitely indicative of wet conditions The occurrence of heath is clearly indicative of an entirely different set of conditions. It is to be feared that some of the expensive experiments in afforestation have been carried out without a sufficient study of the local natural vegetation.

REFERENCES

In 1939 the Cambridge University Press published the magnificent volume of nearly a thousand pages and 162 plates entitled *The British Islands and Their Vegetation* by A. G. Tansley. The Second Edition is in two volumes. Professor

Tansley, editor of the *Journal of Ecology* from 1916 to 1937, had previously edited *Types of British Vegetation* (published in 1911, but for many years out of print) which for over a quarter of a century had been the standard work. The new book not only includes the subject-matter of the *Types* but incorporates a summary of all later research and, in addition, an extensive geographical introduction which the geographer will do well to read for its own sake. Before the inception of the British Ecological Society papers dealing with ecology and plant distribution appeared in various botanical and geographical journals. See especially R. Smith, "Botanical Survey of Scotland," *Scott Geog. Mag.*, XVI, 1900, 385–416, 441–467; XX, 1904, 617–628; XXI, 1905, 4–23, 57–83; (with M. Hardy) XXII, 1906, 229–241; also C. E. Moss, *Vegetation of the Peak District*, Cambridge University Press, 1913.

For modern methods of study see A. G. Tansley, *Practical Plant Ecology*, Cambridge University Press, 1926.

In recent years Sir George Stapledon has initiated several surveys of grassland (see below, pp. 192–193) adopting a broad classification which is both ecological and agricultural. See especially William Davies in *A Survey of the Agricultural and Waste Lands of Wales* (edited by R. G. Stapledon), 1936, and R. G. Stapledon, *The Hill Lands of Britain, Development or Decay?*, 1937.

CHAPTER IX

FORESTRY AND AFFORESTATION

ENOUGH has been said in the chapter on Natural Vegetation to indicate that the climate of the whole of the British Isles is one favourable to the growth of forests, and that one must regard forests as the natural vegetation cover of the major part of the islands at least below 1,000 feet. As we travel about much of Britain, particularly the lowland counties of England, the southern part of Scotland, the valleys amongst the Highlands, as well as the valleys of Wales, we are, perhaps, impressed by the well-wooded nature of the country. But the impression is in reality an illusion, for not six per cent. of the surface of the British Isles is at the present day covered with forest and woodland (see p. 124). The lowlands of Britain are, of course, pre-eminently characterised by numerous small fields, usually separated by hedges, and almost inevitably one sees along these hedges isolated trees which have been allowed to grow up or perhaps were planted at the time of the Enclosures. Viewed from a distance, the isolated trees of the hedgerows and the scattered trees of our numerous parks give an impression of a well-timbered country which is in reality entirely false. Yet in the past forests have played an important part in the economic life of Britain. In the early days the clearing of heavily forested land, particularly the damp oakwoods of the lowlands, presented a task beyond the capability of the early inhabitants of these islands. In the Middle Ages the products of our forests and woodlands played an essential part in the economic development of the country. To quote from an article written some years ago[1]: "The three great uses of wood in the pre-industrial period may be broadly said to be for construction, for domestic fuel and for industrial fuel. In the days when timber occupied a place in domestic architecture even more fundamentally important than it does to-day, when timber was the only material for the construction of ships and when timber rubbed against timber in the moving parts of the coach or the mill wheel, it was strength and durability which counted rather than ease of working. Consequently the old oak beams of the manor house, the massive timbers of the *Victory*, or the elaborately carved panels of a Jacobean sideboard are symbolical standards of value which

[1] L. D. Stamp, "The Forests of Europe, Present and Future." Paper read before the Forestry Subsection, British Association, Glasgow, September, 1928; published in the *Empire Forestry Journal*, VII, 1928, 85–102.

were the essential standards of the Middle Ages. The emphasis is obviously on the hard woods rather than on the soft woods. The association of the latter is rather with the blazing pine logs of the baronial hearth—the second great use of wood in the Middle Ages. Characteristic of the third great use is the now defunct iron industry of the Weald. The presence of large quantities of wood suitable for the manufacture of charcoal was the first consideration in determining the location of numerous industries, of which the smelting of iron was one."

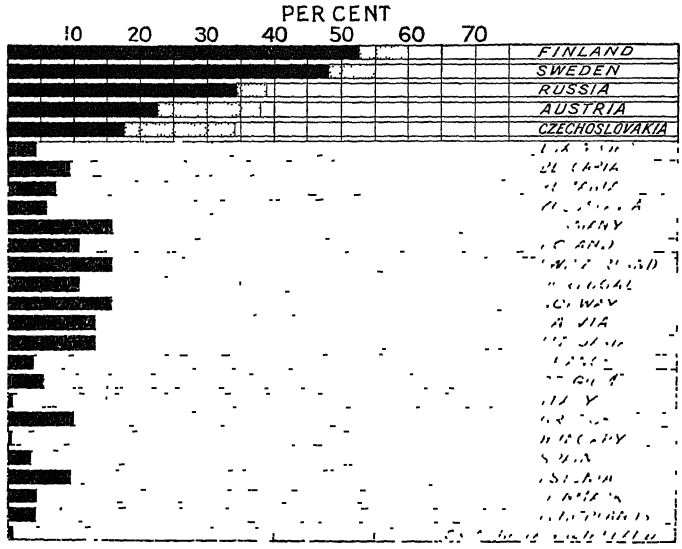


FIG. 89.—The proportion of forest land in the countries of Europe. In black, coniferous forest; stippled, hardwood forest

This diagram was constructed from figures available of the inter-war years, but recent figures of total forest area published by F.A.O. show little general change

The Industrial Revolution may reasonably be held to include the development of coal (including gas and electricity derived therefrom), and later of oil, as the principal domestic and industrial fuels and the rise to first rank of iron and steel as constructional materials. It would almost seem as if timber had become a superfluous commodity. Entirely supplanted by iron and steel in the construction of ships and machinery, very largely replaced in countries such as England as a domestic fuel and entirely as an industrial fuel, timber seemed to have been relegated to a position of minor importance in the economic life of the world.

The history of forestry in the nineteenth century reflects the unconscious reaction of these changes on the public mind. By that time British forests had almost gone: in the new lands of the world

people of British stock were failing to appreciate forest wealth. The reckless depletion of forests by unregulated felling; the "clearing" of enormous areas for agriculture by the incredibly barbarous method of burning off virgin forest; the lack of precautions against fire, and a dozen other things too familiar to necessitate enumeration, all indicate the low ebb of public appreciation of forest wealth.

But the present era is by no means an era which can do without forest products. There are innumerable new uses absorbing huge quantities of timber, such as requirements for railway sleepers, telegraph poles, pit props, as well as the constant demand for the time-honoured purposes of domestic architecture and the construction of furniture. There is the huge and ever-increasing quantity of timber which is required for pulping and manufacture of paper.

The peculiar and serious position of Britain may be judged in several ways. In the first place there is the remarkable contrast with the remainder of Europe. Europe as a whole has roughly 31 per cent. of its surface covered with forest, an average of about $1\frac{3}{4}$ acres of forest for every inhabitant. Compared with the other countries of Europe, the United Kingdom is in the anomalous position of having the smallest proportion of forest area, as well as the smallest area *per capita*, of any country. The useful forest and woodland covering the surface is only about 4 per cent. of the whole and is equivalent to only about one-tenth of an acre per inhabitant. Europe, excluding the British Isles, is roughly self-supporting in the matter of timber, but there is certainly not sufficient surplus to supply the huge requirements of this country. Forest resources have been so depleted in most of the European countries that it is with the utmost difficulty that an export of timber is maintained from such countries as Finland, Sweden, Poland, Norway, Czechoslovakia, Austria, and Rumania. There remains, of course, the greatest potential exporter Russia. All the time there exists in the background the fact that Britain herself could supply, and should supply, a very considerable proportion of her requirements. Despite recent progress, there are still vast areas of heathland and moorland and mountain side of little value which are capable of growing excellent timber or at least wood of economic value.

The attention of the Government was focused on the timber resources of the British Isles during the First World War. Shipping which was really urgently required for the transport of food and troops had to be utilised for the importation of that very bulky commodity—timber. There was ammunition to be made, for which factories were required; they needed fuel and that fuel was provided by the coal mines. Coal cannot be mined without the extensive use of pit props. As early as 1916 the Reconstruction Committee set up a Forestry Sub-committee to consider ways and means whereby, in the event of another national emergency, an adequate

supply of home-grown timber could be assured. The Sub-committee set before it the ideal that the British Isles should be self-supporting

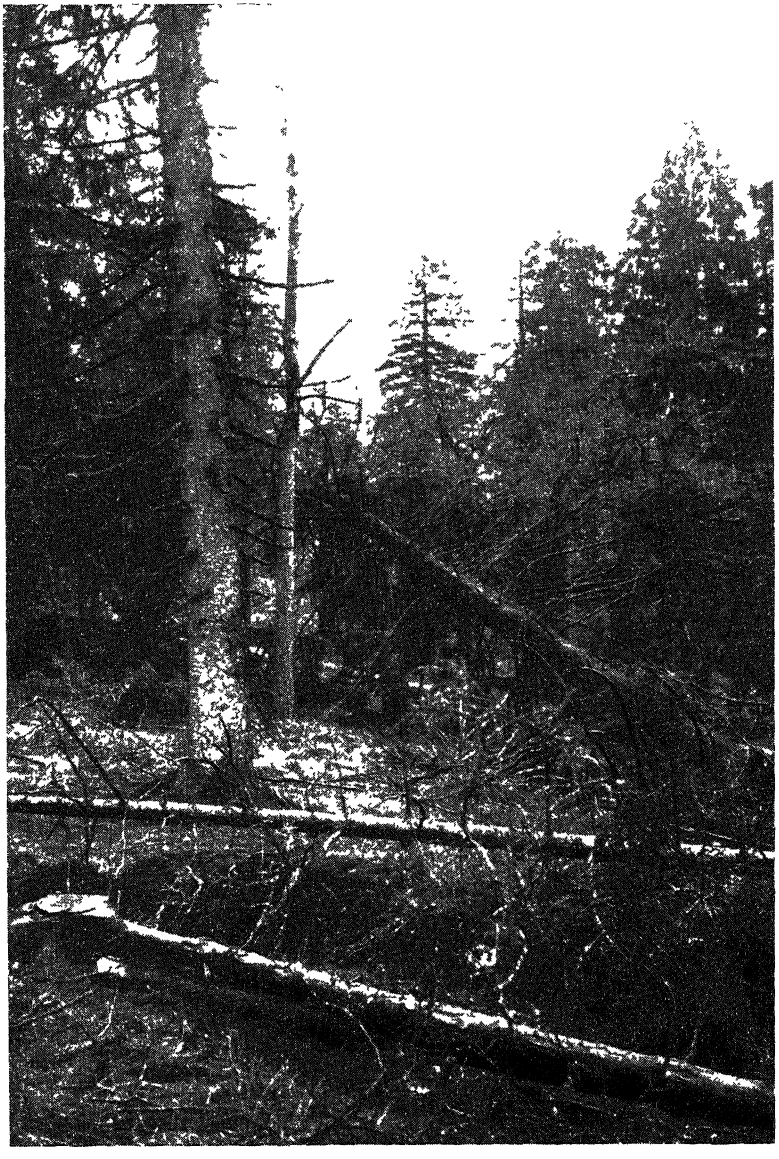


Photo L. D. Stamp

FIG. 90.—Neglect

View in a privately owned British forest, illustrating the neglect which sometimes characterises the woodlands of this country—which could, and should, produce the bulk of its timber requirements

as regards timber throughout a period of at least three years. Amongst the recommendations of the Committee was that a Forestry Commission should be set up, and this Commission was actually appointed in 1919. The Forestry Commissioners calculated that it would be necessary to afforest 1,777,000 acres in order to provide for a national emergency lasting three years. Their scheme provided for the planting of this large area in the course of 80 years, two-thirds of the programme to be completed within the first 40 years. In addition, the existing woodlands were to be rescued from the state of neglect into which they had long since drifted.

One of the first tasks undertaken by the Forestry Commissioners was a census of woodlands of Great Britain and a census of production of home-grown timber. The census was commenced on a trial basis in the autumn of 1921, but was not completed until the end of 1926; most of the work was done, however, during the year 1924. As a result of this census it was found that there were approximately 1,900,000 acres of woodland of all types, including scrub and devastated forest, in England and Wales and rather over a million acres in Scotland. The exact total for the whole of Britain was 2,958,672 acres or 5·3 per cent. of the land surface.

DISTRIBUTION OF WOODLANDS BY TYPES AND SUB-TYPES, 1947

Type	England		Wales		Scotland		Great Britain	
	Acres	%	Acres	%	Acres	%	Acres	%
High Forest:—								
Conifers	331,275	18	97,438	31	439,084	34	867,797	25
Mixed	117,996	6	10,835	3	37,235	3	166,066	5
Hardwoods	580,286	31	77,633	25	97,017	8	754,936	22
Total High Forest	*1,029,557*	*55*	*185,906*	*59*	*573,336*	*45*	*1,788,799*	*52*
Coppice with standards	227,423	12	2,276	1	89	—	229,788	7
Coppice	102,637	6	17,082	5	487	—	120,206	3
Scrub	200,040	10	40,228	13	256,683	20	496,951	15
Devastated	105,415	6	12,013	4	33,636	3	151,064	4
Felled:—								
before Sept. 1939	33,492	2	21,578	7	233,433	18	288,503	8
since Sept. 1939	166,482	9	37,395	11	169,174	14	373,051	11
Total felled	*199,874*	*11*	*58,973*	*18*	*402,607*	*32*	*661,554*	*19*
Total	1,865,046	100	316,478	100	1,266,838	100	3,448,362	100

A similar census of woodlands was carried out in 1947–1949 and the results published in 1952. By that time the total had reached 3,635,362 acres (including an estimated 187,000 for areas under 5 acres not actually measured) or 6·5 per cent. of the land surface. The effects of the work of the Forestry Commission are at once apparent.

A map has been added showing the approximate distribution of woodlands in the British Isles, and it will be noticed that the most heavily wooded portion of England is that immediately south of London, including the counties of Sussex (with as much as 15·5 per

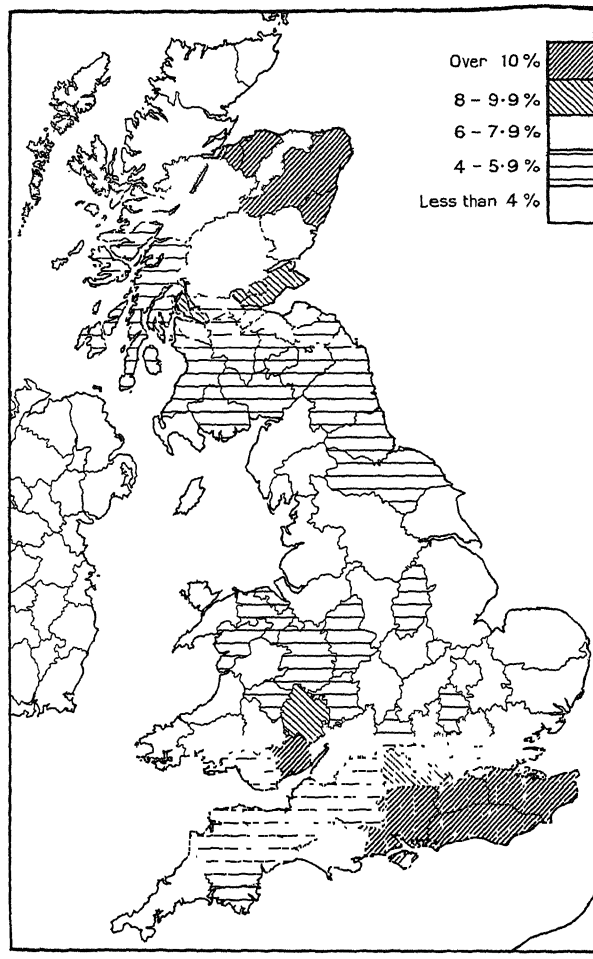


FIG. 91.—The wooded areas of Britain, according to the Census of Woodlands of 1947, showing the proportion of the surface of each county occupied by forest and woodland

cent.), Surrey (15·0), Kent (10·5), and Hampshire (14·9). In Scotland the most densely wooded part is the great Buchan plateau between the Moray Firth and the Firth of Tay, including the counties of Nairn (with 19·1 per cent.), Moray (21·6), Banff (10·0), and Aberdeen (11·6). Farther south, Kincardine has 13·4 per cent.

In the north and west the proportion drops in Scotland to 0·4 in Caithness, and 0·8 per cent. in the islands of Inverness. All other Scottish counties have more than 2 per cent.

Details were also collected at both the 1924 and 1947 Censuses as to the age of the trees in the forests, according to the age classes of 1–10 years, 11–21, 21–40, 41–80, and over 80. For all types of high forest, including coniferous, hardwood, and mixed woods, the following results were obtained for Great Britain as a whole, the first figure referring to 1924, the second to 1947: 1–10 years 8·5 and 14 per cent., 11–20 years 9 and 16 per cent., 21–40 years 18 and 15 per cent., 41–80 years 39·5 and 15 per cent., over 80 years 25 and 14 per cent. These figures show very clearly how all the stands of useful timber (over 20 years and especially over 40 years) were depleted during the Second World War. It must be understood that forest grown for timber has a definite rotation over a number of years. Thus a coniferous forest in Britain is reckoned to be fit for cutting over for timber about every 80 years, that is to say it has an 80-year rotation. Hardwoods, on the other hand, based especially on the oak, have a longer rotation, and forests can only be cut over for large timber every 150 years. Mixed forests are calculated on a 120-year rotation.[1]

In 1924 nearly half a million acres or 16 per cent. of the total area were recorded as felled or devastated in the previous decade and which represented the depletion which took place during the First World War. The plantings which took place from 1919 onwards had in some cases reached a size suitable for pit props, but not for timber when the Second World War broke out in 1939. In the 1947 Census felled and devastated totalled 23 per cent. of the whole area—11 per cent. felled from 1939 to 1947.

Coppice, and coppice with standards, represented nearly 18 per cent. of the total area of woodlands in 1924 but only 10 per cent. in 1947. Of this approximately seven tenths is coppice with standards. Most of this area occurs in southern England. Indeed, practically half of the woods of this description were found in the few counties of the south-east—Kent, Surrey, Sussex, and Hampshire—where the coppice with standards is very largely the remnant of the former covering of damp oakwoods on the heavier soils in this part of England. The produce from these woods was largely hop poles and the decreased importance is due to the smaller demand not only for these poles (replaced by semi-permanent wiring) but also for fence posts replaced by concrete or metal posts.

Scrub represents a considerable proportion (15 per cent.) of the total woodland area. Over half of the whole is found in Scotland, particularly in Argyll and Inverness. There it consists of sparse

[1] These are approximate figures used in the Census Reports. Actually, various rotations are employed when woodland is regularly managed.

stands in birch, found over considerable areas of the Highlands. In the west of Wales a poor cover of dwarf oak is common and similarly tracts in parts of Dartmoor are believed to be true primeval forest remnants.

During the First World War, the volume of timber obtained from British woodlands was estimated at 1,000,000,000 cubic feet or roughly one-third of the volume standing in 1914. The 1924 census estimated the contents of British woodland then as follows, taking no account of hedgerow timber, branchwood or the trees in amenity woodlands and parks.

ESTIMATE OF CONTENTS OF BRITISH WOODLANDS, 1924

	Millions of cubic feet, quarter-girth measurement	
Saw Timber Sizes—		
Coniferous	748	1,546
Hardwood	798	
Pitwood Sizes—		
Coniferous	374	716
Hardwood	342	
Total		2,262

Since the average import of timber in the years 1924–1928 was 10,000,000 tons of 50 cubic feet or 500,000,000 cubic feet, the total available at home in 1924 was only equivalent to 4½ years supply. In subsequent years imports increased steadily reaching 12,822,000 tons, together with 1,794,000 tons of pulp in 1937. Home production remained less than five per cent. of the whole. As the table below shows the Census of 1947 gave an estimate on rather a different basis.

ESTIMATE OF CONTENTS OF BRITISH WOODLANDS, 1947

Trees of over 3 inches diameter, millions of cubic-feet, quarter-girth measurement over bark.

High Forest:	Coniferous	972·6
	Mixed	284·4
	Broadleaved	1248·6
	Total	2505·6
Coppice with standards		152·8
	Grand Total	2658·4

There has long been in Britain a remarkable apathy in matters relating to forestry and afforestation. Yet the climate of the British Isles is essentially a forest climate and trees grow well up to 1,000 feet or even to 1,250 or 1,400 feet at least in the south. Undoubtedly

the greater part of the lowlands was originally forested and even vast stretches of hill moorland are far from natural and owe their existence to deforestation at an early date and the continued grazing of rabbits and domestic animals. With the heavy incidence of death duties and the consequent breaking up of large landed estates, there has become little if any incentive for private owners to plant trees which cannot mature in the lifetime of the planter. Afforestation has become more and more a matter for the state. The Forestry Commission was hampered in the early years after its establishment in 1919 by a grant fluctuating from year to year at the whim of Parliament, and its policy of planting mainly coniferous in response to the known economic demand proved unpopular. Because of the early severance of Britain from the Continent after the Ice Age, the native trees of the country are few and include only one conifer—the Scots Fir (*Pinus sylvestris*). A considerable section of the population had come in recent years to admire the wind-swept open moorland so disliked by Johnson and his contemporaries and to dislike forest and moorland, especially of introduced conifers. The difficulty of planting otherwise than in rows forming rectangular blocks and the monotony of such plantations all of one species and one age added to the loudly voiced criticism of the Forestry Commission. The original mandate given to the Commission was to afforest 1,777,000 acres; in 1943 Government plans were published covering 3,000,000 acres to be afforested and a further 2,000,000 to be replanted and the Commission now manages private woodlands "dedicated" for the purpose as well as its own State Forests. Only land too poor for agriculture is normally acquired for afforestation —either mountain and hill land or poor sandy lowland heaths.

By 1947, 18 per cent. of all woodland in Great Britain was State Forest, including 30 per cent. of all high forest and actually 52 per cent. of coniferous high forest. These figures illustrate the State policy of planting mainly conifers, but the Census showed that oaks occupied 24 per cent. of all high forest areas, followed by Scots Pine, 20 per cent. After Scots Pine the commonest conifers were Sitka Spruce (*Picea sitkensis*), Norway Spruce (*Picea excelsa*), European Larch (*Larix europaea*), Japanese Larch (*L. leptolepis*), Douglas Fir (*Pseudotsuga taxifolia*), and Corsican Pine (*Pinus laricio*), with other conifers totalling only 1 per cent. of the high forest area. After oak chief broadleaved trees were Beech (*Fagus sylvaticus*) 9 per cent of total area, Ash (*Fraxinus excelsior*), Birch (*Betula verrucosa*), Sycamore (*Acer pseudoplatanus*) and Elm (*Ulmus* spp.). Other broadleaved trees totalled less than 1 per cent. of total high forest area.

The State Forests of the Forestry Commission are widely distributed. The largest is Thetford Chase, on the former Breckland of Norfolk and Suffolk with 32,000 acres actually forested; others

in order of size are the New Forest, Forest of Dean (both old Crown Woodlands), and Kielder in Northumberland (an entirely new area of 19,000 acres). All the others are under 10,000 acres though in all the total was 623,000 acres at the time of the Census of 1947. It should be noted that the areas actually acquired are greatly in excess of these figures of wooded or planted area—in 1950 the area of land controlled by the Forestry Commission was 1,668,000 acres.

Afforestation can undoubtedly bring about an amelioration of conditions for human life in many parts of the country. A good example is afforded by the Western Highlands of Scotland.[1] Over most of this area there has long been a steady rural depopulation, commencing with the disruption of the Clan system after the 1745

[*Photo Crown Copyright Reserved*

FIG. 92.—Pit props made from thinnings of spruce, Forest of Ae, Dumfriesshire

rebellion and carried on through later years when the crofting population of the valleys became replaced by a small number of shepherds, and then later the shepherds by an equally small, or smaller, number of gamekeepers and stalkers. The large acreage of deer forest has already been noted. In 1883 it was less than 2 million acres, but by 1930 it had increased to approximately 3½ million; and it must be admitted that this does not represent the highest utilisation of the land. Many of these rough grazings and deer forests have since 1930 been or are being acquired by the Forestry Commissioners. The permanent forest employees have

[1] See J. Claxton: "Afforestation in the Western Highlands and its effect on Repopulation," *Geography*, XVII, 1932, 193–203.
W. Dallimore: "Forestry in the Highlands of Scotland," *Kew Bulletin*, 1910, 239–248.

a cottage and some cultivable land giving them a definite interest in the countryside quite apart from their work in the forests; and each worker's holding means the establishment not of one person only but of a family of four or five. The work in forest areas does not, of course, end with the planting operations, more especially when one remembers that it is not the intention to plant the units purchased for afforestation all at one time, but rather to spread the work over 10 to 30 years. In this case by the time the forest unit has been fully planted it is time to begin thinning—the cutting down of certain trees to provide increased room for selected ones. On this basis it is estimated that every 100 acres of forest will supply permanent employment for one man and his family until the first clear fellings are made when the trees are 60 or 80 years old. Actually, because of the large amount of afforestation work undertaken, the North-west Highlands of Scotland have shown that it requires about one man for every 50 acres. Nor does this represent the full total, for there is obviously a demand for schools, for shops, for professional men, for transport workers supplying motor bus services, and so on, and a permanent rural population of some 50 to the square mile in afforested areas of the Highlands of Scotland is probably not a bad estimate.

Northern Ireland[1]

The position in Northern Ireland is somewhat different from that in Great Britain. In early historical times Ireland was a land of bogs and forests inhabited by small clans who lived by herding, hunting and raiding rather than agriculture. Over the whole the clearing of the woodland came later than in Britain, but was eventually far more complete. That small area around Dublin known as the English Pale where direct English rule was established by the Normans was cleared of forest for military reasons and the clearance was extended to the Central Main so that by Elizabeth's reign it was reported nearly destitute of trees. It was not however till 1608 that the power of the last native chieftain in the northern province was broken and in 1609 began the systematic settlement of Ulster with English and Scottish colonists—the so called Plantation of Ulster. The settlers cleared the woods to make room for agriculture and the process was continued by the Stuarts and the Cromwellian settlement of 1652 and there was a reckless exploitation also for fuel, for the ironworks and for export, so that by 1698 the first of several abortive acts was passed requiring the planting of trees.

Although the Royal Dublin Society from its foundation in 1931 did much to encourage planting and landowners individually did

[1] J. Pimlott, "The History of Afforestation in Northern Ireland," *The Adv. of Science*, IX, 1952, 297–303.

much, Northern Ireland remained a comparatively treeless country. When the Government of Northern Ireland was established in 1921, it became the forest authority. At that time less than 1·5 per cent. of the land area was classed as forest and woodland. By following a policy comparable with that of the Forestry Commission the area has crept up gradually. An average of a thousand acres a year were planted from 1928 to 1948 and lately double that rate. In 1950 the total forest area of Northern Ireland was recorded as 58,000 acres or rather over 1·7 per cent. of the land area.

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CHAPTER X

AGRICULTURE

Introductory

IT is important to realise the position which farming today occupies in the life of Britain. In the course of the great industrial expansion of the industrial revolution and after, when Britain became engaged more and more in the task of supplying manufactured goods to an ever-expanding world market, home production of food came gradually to be neglected, almost forgotten by the growing number of town dwellers. In payment for goods supplied and services rendered, as well as in payment of interest on our overseas investments, there was an automatic flow into the country of food and raw materials. Until the famous period of high-farming in the eighteen-sixties and 'seventies, British agriculture was expanded to feed the growing industrial population. With the repeal of the Corn Laws by the famous act of 1846 there were no longer tariff barriers to hinder the inward flow—a trickle at first but developing into a flood which gradually changed the whole character of British farming and reduced it to a depressed industry in the nineteen-thirties. Sorely strained by the First World War, the Second World War changed Britain from a creditor nation to a debtor nation forced to go out into the world and buy food and raw materials at competitive prices to be paid for by exports no longer eagerly demanded by the world's markets.

During the Second World War the danger of starvation by blockade forced a new development on home farm production. After the war, shortage of foreign currency continued to emphasise the vital importance of farming in the homeland. In the nineteen-thirties Britain was producing between 35 and 40 per cent. of the food consumed and that production was based largely on a huge import of animal feeding stuffs. In the post-war years the aim was to produce 55 to 60 per cent. of consumption and, as during the war years, to rely as far as possible on home production of animal feeding stuffs.

It is quite wrong, however, to consider farming in Britain as unimportant even during the depression years of the nineteen-thirties. The value of produce sold off the farms was ten times that of the fisheries; it continued greater than the output of the mining industry. Although the numbers of farm workers dropped steadily, farmers and farm workers remained well above a million in Britain

so that agriculture retained its place as the largest employer of labour of any industry. Farming occupied a larger number of persons in Britain than in any of the great dominions of the Commonwealth—Canada, Australia, South Africa, or New Zealand. Although only 6 per cent. of the occupied population was employed in agriculture in Britain, about 1 in 10 of every man, woman and child was dependent upon the land directly or indirectly for a livelihood.

About 20 per cent. of the British people are officially classed as "rural dwellers"—they live in "rural districts" as opposed to "urban districts," towns and cities, but only about 10 per cent. really live in the country—in the isolated farms and cottages, hamlets, and villages. But they are well distributed and if we include rough grazing with farm lands, small holdings, allotments and commons used for grazing then something like 84 per cent. of the surface of England and Wales is used in some way or another for agricultural purposes. Because deer forests occupy 18 per cent. of Scotland, the percentage there drops to 73 but rises in Northern Ireland to 89 or 90. Very roughly in Britain nine-tenths of the people live on one-tenth of the surface; the remaining one-tenth of the people are the custodians of nine-tenths of the national estate.

PERSONS EMPLOYED IN AGRICULTURE

Great Britain	1911	1,429,000 or 7·79%	of the occupied population
	1921	1,307,000 or 6·75%	" " " "
	1931	1,194,000 or 5·67%	" " " "
	1951	1,043,700[1] or 5·01%	" " " "
Northern Ireland	1926	147,500 or 15·3%	" " " "
	1951	125,000[2] or 12·5%	" " " "
Irish Republic	1926	648,575 or 53·0%	" " " "
	1946	571,549 or 45·0%	" " " "

[1] England and Wales.
[2] Rough estimate.

A Sketch of the History of Farming in Britain[1]

We have already seen that the natural vegetation of the greater part of the British Isles is deciduous forest. It is clear that there were some areas where the forest was more open than in others, and perhaps more easily cleared, or it may even have been absent. The early settlers in the British Isles were naturally attracted to such tracts. There is clear evidence that it was the damp oak woodland of the lowlands which longest resisted attempts at clearing and cultivation. In many areas the distribution of Saxon place-names

[1] See especially Lord Ernle, *English Farming Past and Present*, 5th ed., edited by A. D. Hall, 1936.

illustrates this quite clearly. The differing values of the various types of soil was, of course, recognised at a very early date. We have a permanent reminder of this fact at the present day in the curious shape of many rural parishes. For again and again parish boundaries are found to be so arranged that the parish encloses good land and poor, warm dry soils, and cold heavy soils (see Chapter XXV, and Figs. 93, 247). It is, of course, probable that the better lands were all settled first, and that the need for expansion involved settling or utilising tracts of poorer land. Quite apart from the different streams of culture which affected respectively the eastern and western coasts of the British Isles and which will be considered in a later chapter, there seems no doubt that the climatic contrasts between the eastern and western sides of the British Isles were responsible again at a very early date for the differentiation of distinct types of farming. In the east, with its greater suitability for arable farming, the nucleated village from which farmers could reach the different types of land in the vicinity are characteristic, whereas in the west, with its greater suitability for pastoral farming, scattered farmsteads or tiny hamlets were the general rule and still tend to persist to the present day, notably, of course, in Ireland, where the village as understood in England is almost non-existent.The site of the settlements was usually determined by an adequate water supply; in the damper country of the west, water was available almost everywhere and made scattered settlement easy.

It was accordingly, especially in the southern and eastern districts of England, that the manorial system developed and became the controlling factor in medieval agricultural practice. The manor was the unit of land holding and cultivation, though there might be two or three manors within the limits of a parish (see Chapter XXV). The lord of the manor held his land at one or more removes from the king; his tenants in turn held varying proportions of the land in return for various services which they had to render to the lord. The land could be divided broadly into three groups—the arable, the pasture, and the waste. The arable land was divided into three, or some multiple of three, open fields, which in turn were divided into strips of one acre or half an acre. The three fields corresponded with the fixed three-year rotation of a winter corn crop (wheat or rye), a spring corn crop (barley, oats, peas or beans, or mixed corn), and the third field bare fallow. The requirements of the period were simple—wheat or rye for bread; barley for beer, cattle, pigs, or sheep for meat. In each of the three large open fields each tenant held a certain number of scattered strips, the original intention being to give the tenant the benefit of variation in land, in good soils and bad. Intermingled were the strips that belonged to the lord of the manor himself and which constituted his demesne; each tenant was required to give a certain number of

days' service in cultivating the strips belonging to the lord of the manor. In heavy land, such as is found over large tracts in the Midlands of England, the strips of cultivated land in the open field were steeply ridged to throw off surplus water, and this ridge and furrow is still found in many parts of the country, although this heavy land has long since been laid down to grass. This once ploughed land of the open field system, with its marked ridge and furrow has been described by Mr. Punch, not inaptly, as the land of England which has been permanently waved. After the harvest the arable land was thrown open to cattle to wander over, the weeds and other vegetation providing them with a certain amount of food; but obviously this was a practice which prevented the growth of winter fodder crops. The meadowland was the lower land down by rivers and watercourses used for the production of hay and divided up in proportion with the arable land. After the hay harvest this

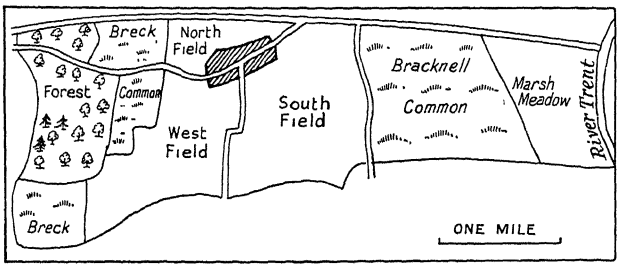

FIG. 93.—A Nottinghamshire parish prior to enclosure, showing the nucleated village, the three fields. the waterside meadows, the common or waste lands, and the woodland

land was usually thrown open to common pasturage. The hay harvest was known as lammas, and hence the name "lammas field" which is sometimes still used in country districts for pasturage by the side of streams. The third division of the manor, the waste land was the origin of what to-day remains as small isolated tracts of common land or commons. On this the tenants had right of pasturage, and in suitable districts the right to cut turf or peat for fuel, and were also entitled to cut brushwood for burning, bracken for litter and reeds for the floors of their houses. From the common land also the tenants could obtain building stones, and other material, for the construction of their houses.[1] On the old manorial farms the

[1] Within 16 miles of London there is the manor of Ashstead, and a board standing on that manor, at least until recently, read as follows:

"All Persons who shall be found felling, cutting, digging, or taking or carrying away timber or other trees or pollards, turf, mould, gravel, clay, peat, sand, stone, furze, heather, or any other material (save and except the Person or Persons authorised by the Lord of the Manor or his Steward) will be prosecuted. Tenants or other persons requiring permission to take any of the above materials are to

level of production was exceedingly poor. Although about two bushels of wheat per acre were used as seed, the yield was commonly only about ten bushels per acre, or approximately five-fold. The yield from barley was little better, and of oats probably less. The conditions of livestock were probably even worse. The stock of all the tenants and of the lord of the manor were herded together and tended by the village cowherd, the shepherd, or the swineherd, as the case might be. Where there was much open downland suitable for pasturage for sheep, these animals naturally were most abundant. In predominantly wooded country the acorns provided an important food for the swine. In well-watered or reedy pastures cattle naturally took their place. Sheep were valued mainly for their wool, which formed an important commodity in English farming from very early times. The ewes were often milked, and the older animals killed for meat. During the open weather the sheep lived on the commons, in winter they were kept in folds, particularly on the fallow and fed on whatever rough pasture might be available. Cattle were kept very largely as agricultural animals. Ploughing by oxen was usual up to the seventeenth century, and did not entirely disappear even in England until the end of the nineteenth century. The cows were kept for milk, but the milk was usually converted into butter and cheese. In spring they were pastured on the commons or on the wetter pastures, already described, by the rivers, and in the latter part of the summer they were turned out on the stubble and fallow of the arable land. Food in the winter was a difficulty, and in the autumn a large number of the older animals were killed off and salted down for a supply of meat. But year after year there is little doubt that for the inhabitants of medieval England swine afforded the principal source of meat. It will be noticed that even at an early date the manorial farms supplied a considerable variety of produce. It was indeed the aim of the manor to be self-supporting both for food and clothing. Rarely was there any surplus of corn for sale, though money was received for the sale of livestock as well as for wool, skins, and a certain amount of dairy produce. The great variety of produce obtained from any one farm has remained an outstanding characteristic of British agriculture even to the present day and will be referred to again.

Quite apart from those areas of the country where the manorial system in its entirety was probably never practised, this strict system began early to break down. The lord of the manor would

apply to the Lord of the Manor. . . . Horses, cattle, sheep, or any other animals found on the said common or waste lands and not belonging to Persons *having rights of Common*, the same will be seized and impounded."

Common rights survive in many other parts of the country, e.g. in Norfolk, and have considerable agricultural importance.

retain for his own use meadows and even arable fields. The tenants took to enclosing portions of the waste land and farming them for their own benefit, at the same time escaping the necessity of giving so many days' service to the lord of the manor by the payment of rent. The occurrence of a plague might deprive the lord of the manor of the greater part of his labour supply on the old system and necessitated the consolidation of holdings and their farming on a different basis, particularly by putting the land down to grass, a single shepherd replacing a number of ploughmen. This occurred notably after the Black Death of 1349. Thus by Tudor times much land had already been enclosed, particularly perhaps in the south-eastern counties.

Towards the end of the sixteenth century, and in the early part of the seventeenth century, there was increasing trade and intercourse with the Continent, particularly with Flanders, and largely as a result of this new crops and stock came to be introduced into England, together with new methods of farming. Turnips and hops seem to have been introduced about this time, together with many of our common garden vegetables—such as cabbages, cauliflowers, carrots and parsnips, as well as a large number of fruit trees. Even more important was the introduction of clover, together with various fodder grasses. The importance of clover and other leguminous crops is two-fold, in that the bacteria which live in the tiny root-nodules of certain leguminous plants, including clover, have the power of absorbing nitrogen from the air and of converting it into nitrogenous compounds which can subsequently be utilised by other plants as food. Thus these crops, instead of impoverishing the soil by taking from it nitrogenous plant foods, actually enrich the soil in these, though they remove others, especially potassium compounds. Further, clover and similar crops supply a winter food for stock, though it is obvious that under the old system when cattle were turned out on the arable fields after harvest that this would be impossible. Hence the improvement in agriculture which came at this period was only possible with the increase in the enclosures. By the beginning of the eighteenth century there had come into operation, instead of the three-year rotation or the three field system, what is now called the Norfolk or four-course rotation. In the first year wheat is grown, in the second year a root crop, particularly turnips. Then in the third year a second corn crop such as barley, and in the fourth year a leguminous crop, clover or beans, restoring the fertility of the soil prior to the growth in the next year of the crop of wheat in the next rotation. It was largely as the result of the introduction of the Norfolk system that England became an important corn exporting country, as it was during the first half of the eighteenth century until the growth of population and the development of industries absorbed

all the food which the farmers could produce. At the same time the yield per acre increased greatly, and from what is known of conditions about 1735 that of wheat was probably about twenty bushels per acre, or at least double that of the medieval system. It has been pointed out that this improvement in agriculture would not have been possible under the open field system. From the time of Queen Anne onwards enclosure was legalised by means of private Acts. The apportionment during the course of enclosure between the lord of the manor and the tenants was usually fair; those who suffered were the small cottagers who had no arable land and therefore no title in the award and who found their common grazing land swept away with the commons. An additional hardship resulted because the larger landowners often took the opportunity afforded by the enclosure to put the land down to grass, so that a single shepherd would often take the place of ten or a dozen men who had formerly worked on the land when it was arable. Enclosure went on gradually all over the country until the General Enclosure Act of 1845. By that time such counties as Suffolk, Sussex, Kent, Essex, Somerset, Devon, and Cornwall, as well as the borders of Wales, had so far been enclosed that they were scarcely affected by the Act. Despite occasional hardships, which it undoubtedly caused, enclosure was on the whole a measure of progress in British agriculture, for it bound together grain production and cattle rearing—"More cattle, more manure; more manure, bigger crops; bigger crops, more cattle." With it came the improvement in agricultural machinery which took place in the eighteenth century. Drainage, which had often been impossible under the open field system, was now widely extended, but it was not until later that drainage by land drains laid underground became general. It is interesting to notice that much of the progress of the period was due to the tenant farmers as well as to the landowners themselves. The tenants had the advantage in this respect—that they had not enormous sums of capital sunk in the land itself. In the enclosed fields both owner-occupiers and tenant farmers could carry out controlled experiments in animal breeding—not possible so long as lands were open. Thus were evolved the now famous English breeds of sheep, such as the Leicester, the Lincoln, and the Southdown, whilst among cattle, Shorthorn, Herefords, and Devon are great meat producers which have now found their way to all parts of the world. In fact, English breeds of sheep and cattle perfected during these times have now tenanted the greater part of the wool and meat producing regions of the whole world. Although much of this work was done by tenant farmers it was often the enthusiasm and the enterprise of the great landowners which created the necessary atmosphere of enterprise and confidence.

The Victorian era was a great period of scientific progress in

British farming. The requirements of the different sown plants came to be scientifically studied, the use of artificial fertilisers began to spread. The first consignments of nitrate of soda arrived about 1830, and Peruvian guano about 1840. In 1843 Lawes, who is famous as the founder of the Experimental Station at Rothamsted in Hertfordshire, began the manufacture of super-phosphates at Deptford, and he quickly proved the value of ammonia salts (which could be made from by-products of the already very important gas-making industry) as fertilisers for farm crops. Foreign feeding stuffs, such as linseed cake and cotton cake, became general. The progress was so great that by 1870 the yield of bushels per acre had risen to thirty. After a terrible period of depression in the early part of the nineteenth century the position improved also as a result of the increasing demand for food from the growing industrial towns. This remarkable period of prosperity and development came to an end about 1874. High prices had been occasioned by the Franco-Prussian War of 1870–1871, but there followed a trade depression and a series of bad seasons. A new factor came into operation. It was the growth of railways and the development of steamship traffic which opened up international trade in agricultural products. Rapid settlement of new land in Canada and the United States and Australia followed, and supplies from new regions began to appear in quantity in the British markets. It must here be pointed out that many crops had been widely grown in the British Isles for which the climate of this country is not pre-eminently suited. One of the best examples is afforded by the cultivation of wheat in Ireland. The damp climate of Ireland with its frequent comparative absence of sun is not really suited to the ripening of grains such as wheat. Consequently, when improvements in overseas transport made possible the supply in large quantities of grain grown under climatic and soil conditions pre-eminently suitable (as in the Prairies of Canada), it became apparent that purely geographical conditions were asserting themselves. Here it may be well to state that the geographical factor in determining what crops can be economically cultivated has become in recent years more and more important. If only this were realised we should not attempt at the present day to encourage by protective duties, bounties and other artificial means the cultivation of crops which can be much more suitably produced in countries overseas where geographical conditions are more favourable. We should, on the other hand, study with greatest care the geographical conditions of this country, and so determine what crops may with greatest advantage be here produced in contrast to countries abroad where conditions for production are less suitable. Under this heading there naturally come such easily perishable commodities as soft fruit, which should be produced near the centres of consumption, and, of course, in the sphere of animal husbandry the

production of fresh milk, which is a great advantage to have produced near at hand. We should tend to leave the production on an extensive scale of such commodities as wheat to overseas areas, since the climate of this country is not so immediately suitable, except in the eastern counties.

Other factors, of course, operated in the general fall in prices, and the great depression in British farming in the late 'seventies of last century. The smaller farmers, especially tenant farmers, went bankrupt, and landowners found huge areas thrown on their hands which they were forced to operate on new large scale methods. There was naturally a considerable rural depopulation. There was a search for new crops which would solve the farmers' difficulties. Many important industries developed as a result, such as that of potato growing in the Fen country, and there followed the steadily increasing concentration on dairy farming. There was initiated an ever-increasing proportion of the land under permanent pasture, and a corresponding decrease in the area under the plough. To some extent only was the abandonment of farming lands by crofters in Scotland offset by the increased proportion of rough grazing, which was improved in parts of England and Wales. The general movement was interrupted in the latter part of the First World War, when the difficulty of obtaining the essential supplies of food grains and other foodstuffs from abroad resulted in the necessity of increased ploughing in the British Isles; but the cessation of the general movement was but a temporary one.

Trends in British Farming, 1919–1938

The above short historical review brings us down to the war of 1914–1918, and we may now summarise the main trends in British farming in 1919–1938. The first is the steadily decreasing acreage under the plough, whether in England, Wales, Scotland, or Ireland. The details of this are given (pp. 172–173), both in the form of statistical tables and of graphs.

It will be seen that everywhere the position was roughly the same. It had become uneconomic with the high cost of arable farming in this country to grow farm crops when there were readily available supplies from overseas countries where the conditions for their production were often more geographically and economically suitable. The statistical tables show at the same time the general tendency for the area under permanent pasture to increase, and corresponding with this, the increase in the importance particularly of dairy farming, and the rearing of sheep, summer beef cattle and pigs. In the third place perhaps the figure of the greatest interest is that showing the movement of the total of crops plus grass. It showed a steady decline and this for two reasons. Poor

LAND UTILISATION

England and Wales (Thousands of Acres)

	Arable land	Permanent grass	Rough grazing
1871–75	14,766	11,799	—
1876–80	14,348	12,802	—
1881–85	13,747	14,838	—
1886–90	13,243	14,560	—
1891–95	12,676	15,166	2,880
1896–1900	12,356	15,239	3,412
1901–1905	11,914	15,545	3,614
1906–1910	11,444	15,903	3,712
1911–1915	11,131	16,013	3,786
1916–1920	11,805	15,075	3,998
1921–1925	11,144	14,805	4,873
1926–1930	10,150	15,368	5,168
1931–1935	9,368	15,750	5,383
1936–1938	9,007	15,777	5,520
1939	8,935	15,709	5,608
1940	10,139	14,433	5,527
1941	11.758	12,829	5,633
1942	12,850	11,643	5,592
1943	14,007	10,363	5,593
1944	14,588	9,756	5,751
1945	14,523	9,810	5,581
1946–1950	14,899	10,228	5,561

Scotland

	Arable land	Permanent grass	Mountain and heathland
1871–1875	3,476	1,085	—
1876–1880	3,542	1,148	—
1881–1885	3,604	1,195	—
1886–1890	3,668	1,208	—
1891–1895	3,543	1,356	—
1896–1900	3,503	1,393	—
1901–1905	3,463	1,428	—
1906–1910	3,392	1,471	—
1911–1915	3,312	1,494	—
1916–1920	3,381	1,380	9,399
1921–1925	3,297	1,422	9,642
1926–1930	3,135	1,532	9,678
1931–1935	3,021	1,593	10,219
1936–1938	2,984	1,591	10,465
1939	2,935	1,623	10,465
1940	3,063	1,463	10,468
1941	3,133	1,238	10,710
1942	3,324	1,109	10,697
1943	3,371	1,057	10,825
1944	3,371	1,053	10,760
1945	3,343	1,082	10,973
1946–1950	3,265	1,152	10,929

land, especially on the moorland margins on hill farms, was abandoned as no longer economic or because the slum conditions

in isolated hill farms were no longer acceptable as compatible with the general standard of living in the country. More serious was the loss to housing and industrial expansion, since this usually fell on good farm land in the lowlands. Over the period preceding 1938 this loss was estimated officially for the Scott Report at between 50,000 and 60,000 acres annually in England and Wales alone and over the same period the total area under crops and grass—improved farm land—dropped by 100,000 acres a year.

The War Years 1939–1945 and After

The depressed state of farming in the nineteen-thirties, alarm at the loss of food-producing land and hence a lowering of potential production should such a national emergency as another war arise, had already led the Government to introduce measures designed to stimulate production. A marketing act was passed in 1931 to facilitate organised collective action by farmers in marketing; quotas and tariffs were reintroduced; subsidies and grants for specific purposes were made. In 1938, when war threatened, plans for a complete state control of farming and farm production were perfected so that when war did break out the following year all was ready.

The Government had prepared a nutrition policy and scheme

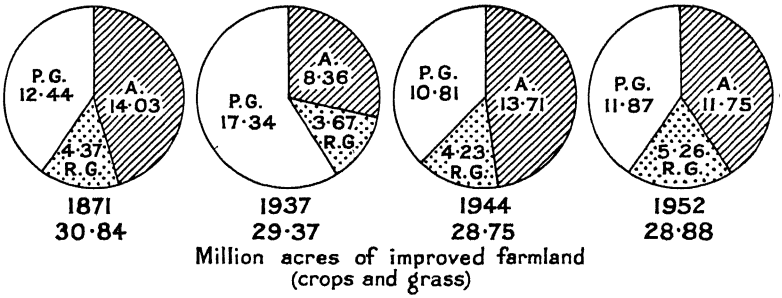

FIG. 94.—The changing use of farmland in Great Britain, 1871–1952

for feeding the people: the Minister of Agriculture was given his target for total home production. The Minister allotted its share to each county and delegated his powers of control to the County War Agricultural Executive Committee in each. The Committees consisted of local farmers of repute, land-owners, land agents and others who understood local conditions and commanded respect. They helped by advice and in many practical ways—loan of men and machinery for example—each farmer to do his best and become an "A" farmer (average were classed as "B," below average as "C") and in the rare event of non-compliance or inability through age or infirmity to improve they had powers to take over and work the land themselves. The core of the wartime policy was ploughing, because plough land is more productive than permanent grass and is more

flexible in the sense that many crops (potatoes, turnips, swedes, cabbages, etc.) can be used either for direct human consumption or feeding to animals. Emphasis was on greater production of grain, potatoes, sugar beet and milk—with a resulting lower pro-

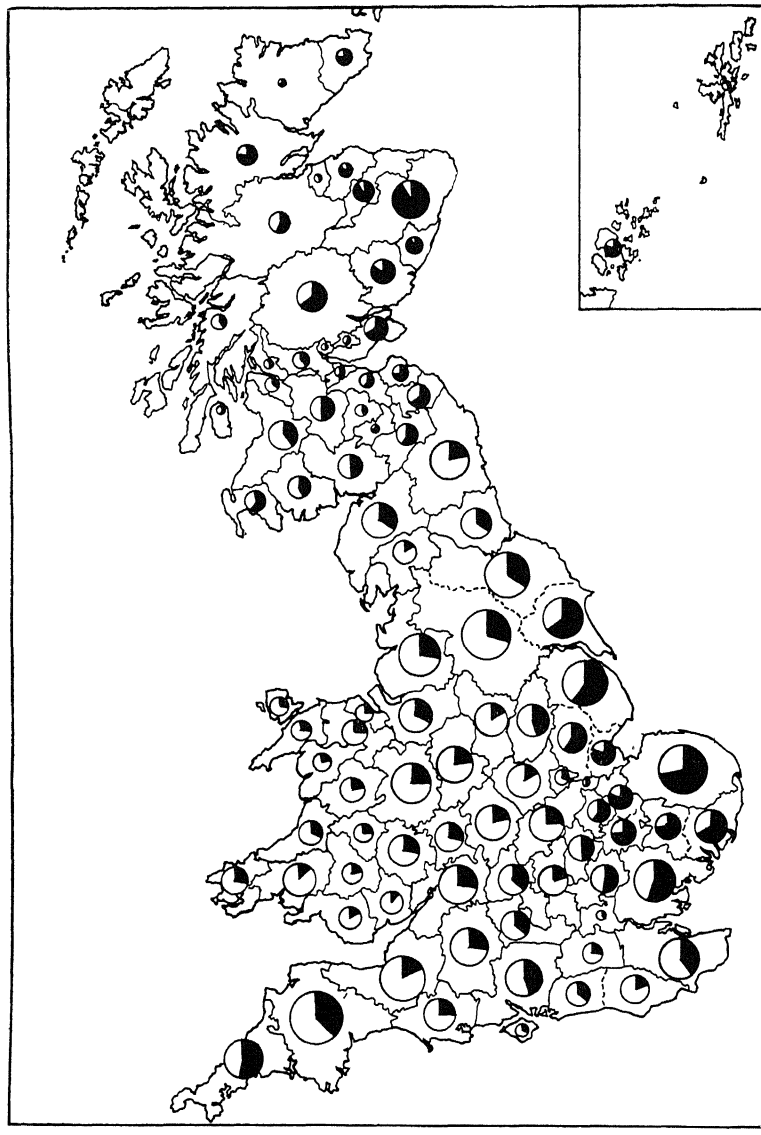

FIG. 95.—The Use of Farm Land in Britain, 1937

This map shows that arable land was mainly important in the drier counties of eastern England and in Scotland. Each circle shows area of arable land in black, permanent grass white

duction of meat. Tractors and many types of implements were both made at home and imported so that Britain became the most highly mechanised farming country in the world; young women of the Women's Land Army replaced young men and, apart from

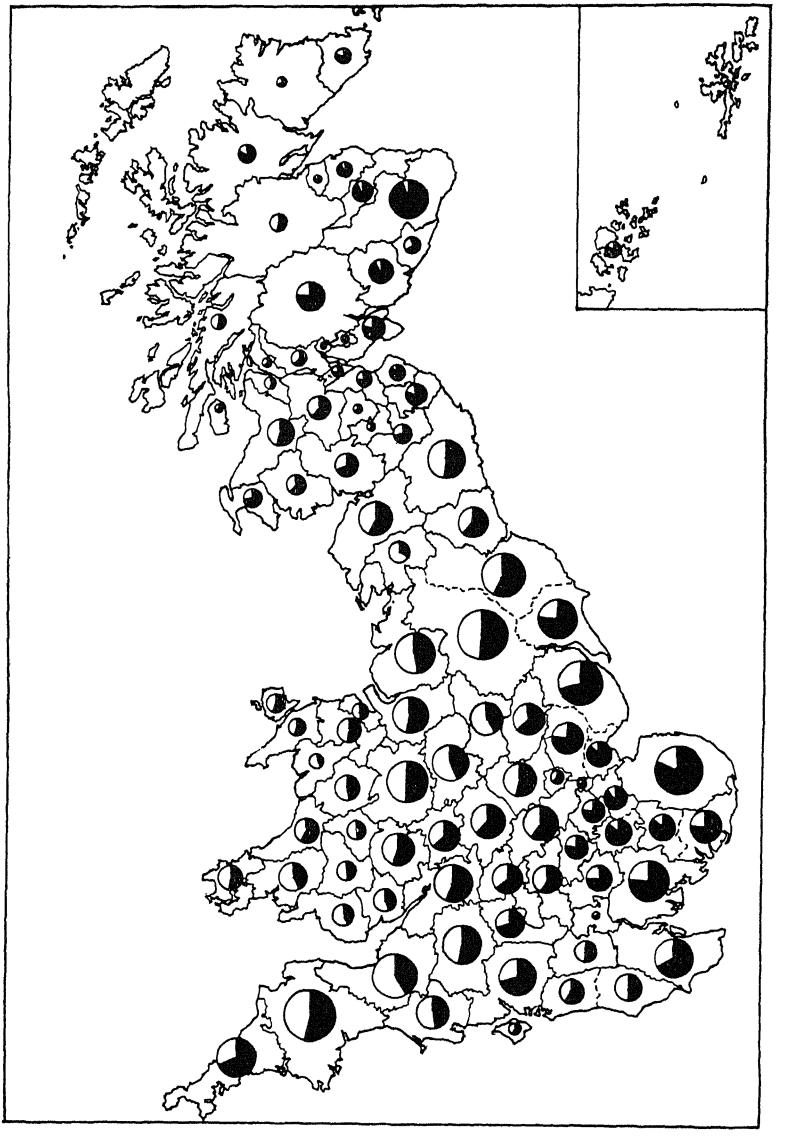

FIG. 96.—The Use of Farm Land in Britain, 1944
This map shows the effect of the war-time ploughing campaign

Prisoner of War labour used later, the total labour force was not increased. As a result bread grains (wheat and some rye) increased 30 per cent., the acreage under potatoes was doubled and production of milk increased.

After the war the Agriculture Act of 1947 adapted to peace-time conditions some of the best features of the wartime effort. The farmer was given minimum prices agreed in advance and a guaranteed market for a wide range of his products; in return County Committees (constituted on a more democratic basis) were given powers to ensure a good standard of husbandry, including conservation of soil and maintenance of fertility. Various forms of grants—for hill farms, marginal land, ploughing old grass and so on—were maintained or introduced and the five-year plan formulated in 1947 aimed at a net production 50 per cent. over pre-war.

Characteristics of Present Day British Farming

In a broad sense British farming may be termed intensive as opposed to the extensive farming widely practised in newer lands, such as Canada, the United States, Australia, and South America. In other words, the British farmer cultivates "intensively" a comparatively small tract of land producing a variety of crops, whereas the extensive farmer, such as the wheat farmer, frequently devotes himself almost exclusively to the production of one crop and small quantities of subsidiary crops for his own use. Intensive farming involves manuring, and the practice of crop rotations is very usual. The second great characteristic of British farming results from this. It is that the British farmer, speaking generally, produces small quantities of a great variety of products—food crops and animal products. We have already traced the rise of the Norfolk or the four field system in place of the old three field system. It was during the scientific development in farming in the nineteenth century that this in turn gave place to a much greater freedom of cropping with many varied rotations such as:

1st year . . .	wheat
2nd year . . .	potatoes or other root crop
3rd year . . .	oats or barley or beans
4th year . . .	barley
5th year . . .	clover or sown grass (*e.g.* rye) or leguminous crop.

There is, however, a marked tendency to break away from strict rotations. Longer lays are adopted in many areas, especially in the west where grass may be grown for 8 to 12 years and the land ploughed for one or two.

A moment's reflection will show that the farmer who practises rotation of crops, however small his farm may be, will have at any one time in course of production many different crops, at least five in the Norfolk system. The wheat is probably intended for sale

to the miller, for grinding into flour and so for human consumption. Of the root crops the potatoes may be intended for human consumption, but mangolds or turnips are more likely to be intended as winter feed for sheep and cattle. The oats may be consumed partly as fodder for horses working on the farms; it is unlikely that they are for human consumption, though some may be for feeding to stock, or for sale to corn chandlers. The barley again is not destined for direct human consumption, but for sale to maltsters for the manufacture of beer, or for feeding to pigs and other stock. Clover and grass are clearly not grown for human consumption, but for feed for stock, particularly cattle. Thus the farmer, in addition to being concerned with at least five different crops, is further concerned with horses, cattle, sheep, and probably also with pigs. Until the wartime development of guaranteed markets and prices it was the marketing of the great variety of products which was the farmer's great difficulty. Agricultural produce was passed from the producer into the hands of the country dealer, then to the wholesaler, then to the retailer, and finally to the consumer. Additional links in the chain become apparent when some process is necessary, as in the curing of bacon in the bacon factory, and the canning of fruit in the fruit-canning factory. Although the number of middlemen has been reduced, there are still many functions for them to perform. In many ways the Ministry of Food has taken on the functions of the middleman. These functions may be grouped as follows:

(*a*) *Assembling.*—In general the production unit of the farm is small. The middlemen or farmers' own organisations such as co-operatives assemble larger numbers or larger quantities of agricultural produce.

(*b*) *Sorting and grading*—The gradual development of the idea of standard grades replacing the old individual judgment is a great help in marketing, since it is possible to purchase without actually seeing the goods or the vendor. There are various methods of establishing standards, sometimes by producers or trades organisations, as in the case of jam, corn, and cheese; in other cases there are official standards set up by the State, especially in the case of agricultural produce intended for export, as with Irish poultry. Until recently standardisation in Great Britain was behind; but voluntary standardisation under the National Mark system was introduced by the Ministry of Agriculture in 1929, and now standards have been laid down for many commodities.

(*c*) *Packing.*—One of the improvements desirable in Britain is the adoption of standard packages, instead of a great variety of shapes and sizes of packages.

(*d*) *Transportation.*—There is still a considerable degree of superfluous movement of agricultural produce; Milk sent from west

Wales to London crosses that sent from Hereford to South Wales.

(*e*) *Processing or Semi-manufacturing.*—Many agricultural products require canning, drying, quick-freezing, or other forms of processing.

(*f*) *Storage.*—This function is necessary because the farmer usually lacks storage facilities.

(*g*) *Financing.*—There is usually a considerable lapse of time in agricultural industries between the expenditure, for example, of money for seed and the time for which money is received for the resulting produce, or from the time of outlay of capital on young stock and the receipt of money for the ultimate products.

The problem of distribution is still a major problem. There are 2½ million engaged in distribution in Great Britain, not of course all in foodstuffs. Whilst it is estimated that 25 per cent. of all retail trade is in the hands of the multiple shops and main stores, and a further 10 or 15 per cent. in the hands of retail co-operative societies, more than half the retail trade is in the hands of single shops. To each such commodities as vegetables and fruits have to be distributed.

In the post-war years the control of the Ministry of Food and the rationing of foodstuffs slowly disappeared, but in 1953, rationing of butter, cheese, fats, bacon, and meat still remained. This meant, in each case, central buying by the Government and the distribution equally throughout the country. With other commodities the old marketing problems again come to the fore. Scarcely anyone needs to be reminded of the results of co-operative organisation in marketing and its beneficial results in such cases as that of the Danish farmers and their bacon and butter industry; or of the Californian fruit growers with their oranges and other fruits; or of the South African farmers with their oranges and other fruits; or, again, of the New Zealand farmers with their butter. Co-operation has become firmly established in the Irish republic and in Britain there are some successful trading corporations of farmers, but there have been many failures. What are the reasons for this failure to organise on a co-operative basis? In the first place, co-operative selling means working to contract, and the production and regular delivery of the standardised article for the standardised price. But the British farmer is an individualist. This is at once his strength and his weakness. His markets are often near at hand, and there is the thrill of the auction when high prices *may* be realised—prices perhaps considerably in excess of a contract price previously arranged with a co-operative society. Thus co-operative bacon factories established in this country failed largely because they were not able to secure a regular supply of pigs—the farmers sending their pigs to market in the ordinary way when prices rose. A new position was created by the passing of the Agricultural Marketing Acts of 1931 and 1933,

which give certain powers to the Ministry of Agriculture to organise co-operative marketing. The marketing of hops was one of the first taken in hand, and was followed by pigs, milk, fat stock, and potatoes, and in Scotland by raspberries.

There is no doubt that the work of the Milk Marketing Board has had a great influence on the development of farming since its inception. To a very large proportion of farmers the monthly milk cheque has become the basis of their financial stability. They produce the milk, under conditions which are subject to inspection, they place their churns on a wayside platform where they can be collected by the daily milk lorry and there the farmers' responsibilities end, provided he maintains the requisite standard of quality. Dairy farming, for liquid milk production, has become the leading type of farming and an adequate supply of milk played a large part in maintaining the nation's health in wartime.

Types of Farming in Britain

There are very marked contrasts between one part of Britain and another in the type of farming. In the main the reasons are to be found in the physical conditions of the land, in relief, soil and climate, though accessibility—especially to roads and so to markets —also plays a large part. Although hill sheep farming would seem to have little if any connection with intensive market gardening or small holding round a great city, in reality British farming forms a closely integrated whole. It is the hill farms which breed and rear the healthy young stock to build up the lowland farmer's dairy herds or to supply the grazier who fattens animals for the butcher: the sugar beet farmer needs cattle to benefit from the "tops" and the sugar mill has its output of pulp for cattle feed. This integration must always be remembered when the varying types of farming are under discussion.

A distinction was formerly made between "arable farming" and "grassland farming." Indeed this distinction was made on the Types of Farming map prepared by the Ministry of Agriculture as late as 1937. The modern concept, now widely held, is that all land which can be ploughed benefits by being so treated and the "grassy shires" such as Leicestershire have again taken on their medieval appearance by showing a wide scatter of ploughland. Elsewhere, as in the west, the aim is to "take the plough round the farm," so that, for example in Cornwall, few fields remain untouched in the course of a few years. Nevertheless the truly arable counties remain the eastern counties where grain crops will ripen whilst the best crop in much of the wetter west and midlands is still grass or "seeds" (mixed grass and clover deliberately sown) grown for fodder.

Crofting.—Crofting may be described as the most primitive type

of farming still found in Britain and is characteristic of the remoter or less accessible parts of the western Highlands and islands of Scotland. Although the single-roomed croft, built by the crofter with his own hands from materials gathered locally, is a thing of the past, the dwelling is still a humble single-storied building of two or three rooms often adjoining the cow byre or other farm buildings. The crofter cultivates by hand a small area with vegetables for himself and family, some winter feed for the sheep which graze for most of the year on the rough herbage of the neighbouring hillside. Unlike the Irish, the Scottish crofter relies little on pigs; a cow or two and barnyard poultry are usually present. His cash income is derived from the sale of an occasional calf and lambs. In the past oatmeal ground from his own small oat crop was a mainstay of diet, but the croft has become less self-contained. Indeed unless crofting can be combined with forestry, fishing or work such as gamekeeping or shepherding for a large landowner the young people move away to better conditions.

Hill sheep farming.—Hill sheep farms are usually found on the margins of mountain moorland—over several hundred acres of which the sheep roam except in winter—and the farmhouse is often some distance from a public road and so difficult of access. Round the farmhouse is a small area of grass and arable land—producing crops for winter feed. The life is hard and lonely, the returns small, but both the production of healthy young animals and the use of hill grazing are important in the national economy, hence the financial assistance given to hill sheep farmers by the State.

Rearing.—Under conditions only slightly less severe than those of the hill sheep farmer, the chief occupation may be the breeding and rearing of calves up to the age when they can be sold to the lowland dairy farmer to build up his herd or to the grazier who will fatten the animals for meat.

Mixed farming.—Over much of the wetter west and south-west of England and Wales, especially where long leys are the common practice—land being ploughed and cropped for two or three years and then sown down to grass for seven to ten—the farmer has many interests. He often favours dual-purpose cattle breeding and selling the male calves for veal or for fattening as beef, keeping the female calves for his own dairy herd of a few animals which will bring him a monthly milk cheque. He probably keeps sheep of the breed popular locally, he probably sells eggs and sometimes poultry to a local egg-packing station. On the side he may derive considerable profit from catering to summer visitors.

Beef farming.—In certain fairly well marked parts of the country of which Leicester and parts of the neighbouring counties affords a good example, the main occupation is the fattening of cattle, and to a less extent sheep, for slaughter. Fatting or fattening pastures must

be of good nutritious strains of grass and clovers: provision must be made for winter keep with hay, dried grass, silage, kale, root crops, and various types of cattle cake.

Dairy farming.—The keeping of cows for milk has become the major occupation of farmers over a large part of Lowland Britain. The farms must be accessible by a hard road for the milk to be collected daily: the provision and upkeep of suitable buildings involves a large amount of capital though in recent years dairy farming has spread to open lands such as the Hampshire and Wiltshire downs with the use of portable milking apparatus.

Arable or Crop farming.—Whilst much of the east of England is ploughland and the farmers sell wheat, barley, oats and sugar beet off the farm most of them keep animals also and milk is often important. In the north, in Scotland, both dairying and fattening are based on arable rather than permanent grass. Only in some of those parts of eastern Britain with the best soils—notably Fenland—do animals tend to be absent and the farmer to rely essentially on cropping.

Market gardening, horticulture, and fruit farming.—Such intensive and specialised types of farming exist only where there is a combination of favourable physical factors (such as good deep loamy soils, and local climate with low rainfall, free from frost in crucial periods and good sunshine) and economic factors (such as nearness or access to markets, casual labour supplies when needed for harvesting).

Pig and Poultry farming.—These specialised types of farming require little land and the poorest land, especially if it is well drained, will serve. Both pigs and poultry are "good converters" of vegetable food and both mature quickly, giving good returns.

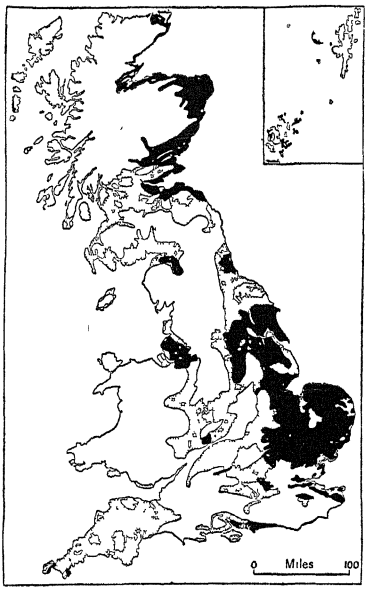

FIG. 97.—The chief arable areas of Great Britain

Main areas in black; mixed arable and grassland dotted. In England it is easy to see that the chief factor concerned is climate. In Southern Scotland the same factor operates, but in the Highlands of Scotland it may be said that if the land is worth "improving" from the main mass of moorland it is ploughed rather than put down to permanent grass

The Agricultural Output of the United Kingdom

We are now in a position to examine the relative values of the principal types of produce which are sold from off British farms,

This of course takes no account of produce retained on the farm. Frequently the main efforts of the farmer will be directed to the growing of feed crops for his own animals: this shows only as a cash receipt for milk or live animals.

In view of the changed and changing value of money the output has been expressed as a percentage of the total for representative years. The position before the depression of the nineteen-thirties is contrasted with the post war. This table shows at a glance the

THE AGRICULTURAL OUTPUT OF THE UNITED KINGDOM

	England and Wales Census 1925	Scotland Census 1925	Northern Ireland Census 1925	United Kingdom 1925	United Kingdom 1949–1950
	per cent.	per cent.	per cent.	per cent.	per cent.
I. FARM CROPS— . .	**20·5**	**18·9**	**19 0**	**20·2**	**19·2**
Corn	10·7			10 5	8·0
Potatoes . . .	5·3			5 2	7·6
Sugar beet . . .	0·5			0·5	2·1
Hops	1·5			1 5	} 1·5
Hay, straw, etc. . .	2·5			2·5	
II. LIVE STOCK AND LIVE STOCK PRODUCTS .	**68·6**	**79·4**	**78 4**	**70 8**	**66·2**
Live stock	35·0			36·2	21·0
Milk and dairy produce	25·6			26·4	30·5
Poultry and eggs . .	6·7			6·9	14·0
Wool	1·3			1·3	0·7
III. FRUIT, VEGETABLES, FLOWERS, ETC. . .	**10·9**	**1·7**	**2 6**	**9 0**	**12·6**
Fruit	4·3			3·5	3·3
Vegetables . . .	3·7			3·1	7·8
Flowers	0 7			0·6	1·5
Glasshouse produce .	2·1			1·7	—
Honey	0·1			0·1	—
Total in £mn. .	225	49	15	289	906

relatively small value of farm crops. Even amongst these the high place taken by such specialised things as the recently introduced sugar beet is noteworthy. The comparatively high figure for live stock on the other hand indicates the importance of home-killed beef, mutton, and pork. There is every reason for the British farmer to concentrate on this work, as his country produces the rich pasture grasses which are so eminently suitable for fattening. Moreover, the mildness of the climate permits cattle to be kept out of doors during most of the year. The remarkably high place occupied by dairy produce is indicative of the tremendous advantages of a

fresh daily supply of milk, sent almost direct from the producer to the consumer within the course of 24 hours. The advantages of fresh milk may be compared with the advantages of fresh eggs, and it will be seen that eggs alone form an item of very great value. The almost insignificant figure for wool is interesting when one compares this with the Middle Ages when wool was the staple product and export.

The Spatial Distribution of Crops

The dominance of arable farming in the east results in a concentration of all the main crops on the eastern side of the British Isles, and we will now proceed to examine the present distribution of the leading crops and attempt to evaluate the factors which are determining that distribution. Before doing so it will be useful to give a table showing the acreages under the principal crops at the present time in the British Isles.

ACREAGE, YIELD PER ACRE AND TOTAL PRODUCE OF THE PRINCIPAL CROPS IN THE UNITED KINGDOM, 1938 AND 1950

Crop	1938			1950		
	Acreage (thousands)	Yield per Acre	Total produce (thousand tons)	Acreage (thousands)	Yield per Acre	Total produce (thousand tons)
Wheat	1,928	20·4 cwt	1,965	2,479	21 0 cwt	2,606
Barley	988	18·3 ,,	904	1,778	19·2 ,,	1,711
Oats	2,395	16·6 ,,	1,992	3,105	17·3 ,,	2,692
Potatoes	733	7·0 tons	5,115	1,235	7·7 tons	9,507
Turnips and Swedes	753	14·3 ,,	10,710	599	15·4 ,,	9,216
Mangolds	219	17·0 ,,	3,705	277	23 7 ,,	6,498
Hay	6,406	21·0 cwt	6,127	5,902	25 0 cwt	6,315

Wheat.—The acreage under wheat in the whole of the British Isles in the year 1931 was 1,271,000 acres, the lowest total ever recorded. Of this area, 1,197,000 acres were in England and Wales, leaving only 50,000 acres in Scotland and 24,000 acres in Ireland. The total production in the same year was 950,000 tons in England, 12,000 tons in Wales, 48,000 tons in Scotland, 24,000 tons in Ireland, making a total for the whole of the British Isles of about 1,034,000 tons, compared with an import in the same year of roughly 5,968,000 tons. Following the abandonment of Free Trade by the National Government in 1932 and the introduction of a "Wheat Quota," acreage rose in the United Kingdom to 1,928,000 in 1938 (England and Wales 1,830,000; Scotland 92,000). Acreage in Eire jumped to 94,000 in 1934 and 163,500 in 1935. The war time effort produced a maximum acreage in the United Kingdom of 3,464,000 acres yielding 3,447,000 tons in 1943. Fig. 98 refers to the depression year 1931. It illustrates the remarkable concentration of wheat cultivation in the East Anglian counties which have the combined advantages of a low rainfall, a comparatively high summer temperature and a good amount of sunshine,

and large tracts of undulating or level land suitable for ploughing and with fertile mixed soils. In Scotland it will be noticed that the small amount of wheat cultivation is restricted mainly to the south of the country and to its eastern margin; where again the advantages of a comparatively low rainfall—less than 30 inches—are enjoyed. The northernmost extension of wheat cultivation is actually on the

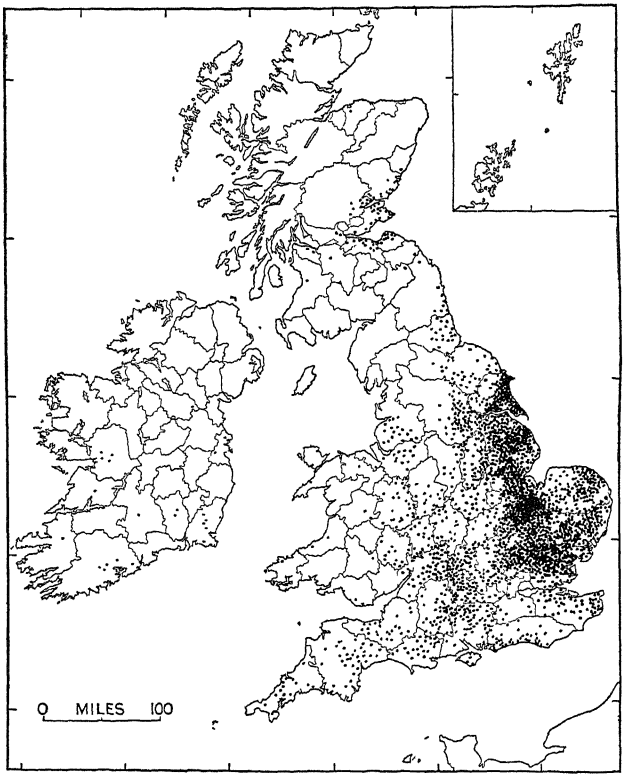

FIG. 98.—Map showing the distribution of wheat cultivation in the British Isles
Each dot represents 500 acres in 1931, the year when acreage reached its lowest recorded and when wheat was being grown only where physical conditions were especially favourable

good red soils of the Old Red Sandstone around Moray Firth. It is, however, broadly correct to state that in the British Isles the 60-degree isotherm for the month of July roughly marks the northern limit of *significant* wheat cultivation. Just to the south of this line lie the Vale of York and Holderness. Wheat grown under conditions of too much moisture is difficult to harvest because of liability to disease. The distribution of wheat cultivation in the British Isles suggests two different types of limit. Broadly speaking, it

may be said that the possible limits of cultivation of any crop are determined by geographical, primarily by climatic, conditions. The limits so determined may be described as the ultimate or the geographical limits. As far as wheat is concerned it may perhaps be said that this limit is almost reached in the north of Scotland, and that the Plain of Caithness, the Orkney and Shetland Islands lie outside the limit; but the whole of Ireland, Wales and England, and the southern two-thirds of Scotland are definitely within the limits so defined. But it is found in the case of any crop that as one approaches the ultimate limits possible for cultivation there is usually a belt where crops are uncertain and in some years may fail completely though in other years bumper crops of good quality encourage the gambler. Thus there is a second inner limit of cultivation which may be described as the limit of large scale cultivation or perhaps as the economic limit of cultivation. Within this limit natural conditions are sufficiently suitable *ceteris paribus* for an

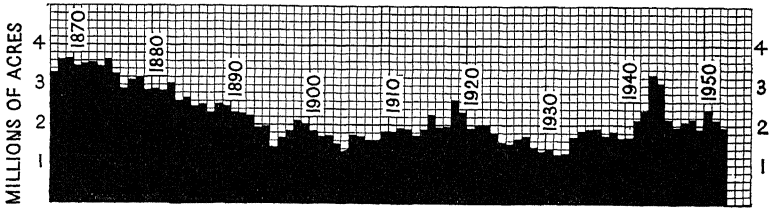

FIG. 99.—The decline in acreage under wheat in England and Wales

annual crop to be assured and failures are rare. Here too, a given crop can be grown in competition with others. In broad terms, the economic limit for wheat is reached and passed in the British Isles, since it may be said to correspond roughly with the 30-inch rainfall line on the west, and roughly with the 60-degree July isotherm on the north, bearing in mind that there are certain specially favoured patches of land farther north which may be regarded as islands or outliers having the suitable conditions. On this basis the southern and eastern counties of England and the Midlands are the only areas where wheat cultivation should be encouraged. The whole of Ireland is excluded, the whole of Wales, much of western England, and the greater part of Scotland. Actually in the nineteenth century and earlier when competition from foreign grown wheat was unimportant, the grain was grown in large quantities over the fringing tracts outside what are now the economic limits. But conditions in that outer fringe were certainly never near the optimum necessary for the crop. This is extremely important, because it is frequently urged that the decline in wheat cultivation in such areas as Ireland is due primarily to economic and historical causes. The truth would

seem to be that Ireland, like many another country, was producing a crop for which the country was not climatically suited. Detailed agricultural statistics have been collected in Ireland since 1847, in Scotland since 1871, in England and Wales since 1867. The total given below shows the maximum acreages recorded under wheat.

England and Wales	3,404,000 acres—1871–1875
Scotland	135,700 acres—1872
Northern Ireland	89,403 acres—1858
Eire	671,448 acres—1847

In Ireland wheat has never been a crop of primary importance. In what corresponds to Northern Ireland, even at the time of its maximum extension in 1858, it only occupied 8 per cent. of the ploughed area. in what now corresponds to the Irish Republic its percentage was even less. Compare this with the fact that even as late as 1925 wheat occupied 28 per cent. of the total arable area in the English counties of Huntingdon and the Isle of Ely, where conditions approach as near as possible to the optimum in this country. Elsewhere where natural conditions were less favourable, acreages dwindled from the seventies to be halted temporarily in 1917–1918, until positive action by the Government in the nineteen-thirties halted the decline. Wartime needs put the acreage in 1943 almost back to 1871 and wheat was grown in every county.

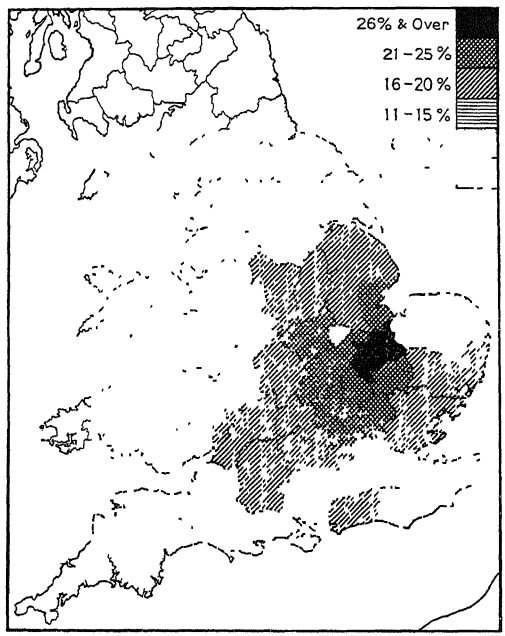

FIG. 100.—Map showing the percentage of arable land in each county devoted to wheat (Census of 1925)

This wartime expansion was in part made possible by selection of special strains suitable for local conditions. The majority of wheats grown in Britain were soft wheats not very suitable for bread making though of high quality. British strains of harder wheats, such as Yeoman and Holdfast, were developed and their cultivation extended. In the cool northern counties such as Durham and

Northumberland Swedish wheats did well, in the dry east, Dutch types, such as Wilhelmina and Little Joss, in parts of the south, wheats of French origin. The influence of climate is unmistakable.

The bulk of British wheat is winter sown, and there is a remarkably high yield per acre. For the ten years 1921–1930 the yield in England and Wales averaged 17·7 cwt. (32·0 bushels) per acre, the weight averaging 61·9 lb. per bushel. It is interesting that near the limit of wheat cultivation where the crop can be grown in favoured localities the yields are often extraordinarily high. In Scotland, in the census year 1925, it reached 22·4 cwt. or 40·5 bushels per acre. In 1941–1950, despite a very bad year in 1947 the yield over the United Kingdom averaged 19·5 cwt. (36·5 bushels) and in 1949 actually reached 22·5 cwt. (42 bushels). In round figures, British wheatfields yield a ton an acre.

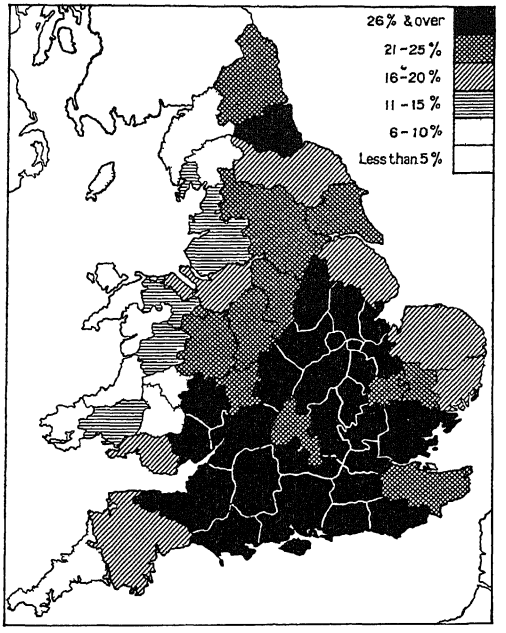

FIG. 101.—Map showing the percentage of arable land in each county devoted to wheat (Wartime effort of 1943)

Barley.—Thriving on lighter poorer soils, the conditions for the cultivation of barley resemble generally those for wheat. There are two main points of difference. Barley is even less tolerant of excessive moisture than wheat and tends to be still more restricted to the drier sides of the islands of Great Britain and Ireland. This is beautifully shown in the case of Ireland where barley cultivation is virtually restricted to the south-eastern corner of the uplands of Wexford, and in the sheltered valleys farther in the interior, or in the small patch of comparatively dry land round Dundalk farther north. Similarly in Scotland it is essentially along the eastern coastal fringe that barley can be cultivated. In England and Wales there is once more a concentration of the crop in the counties of eastern England. On the other hand, barley has a greater northern extension than wheat. This may be partly due to the fact that

barley can take advantage of the longer days of sunlight in the summer and so will ripen while wheat will not.[1] Those who have travelled in northern Finland or Sweden or Russia will have become familiar with the crops of barley ripening possibly a hundred or more miles within the Arctic Circle. Thus the northern limit of

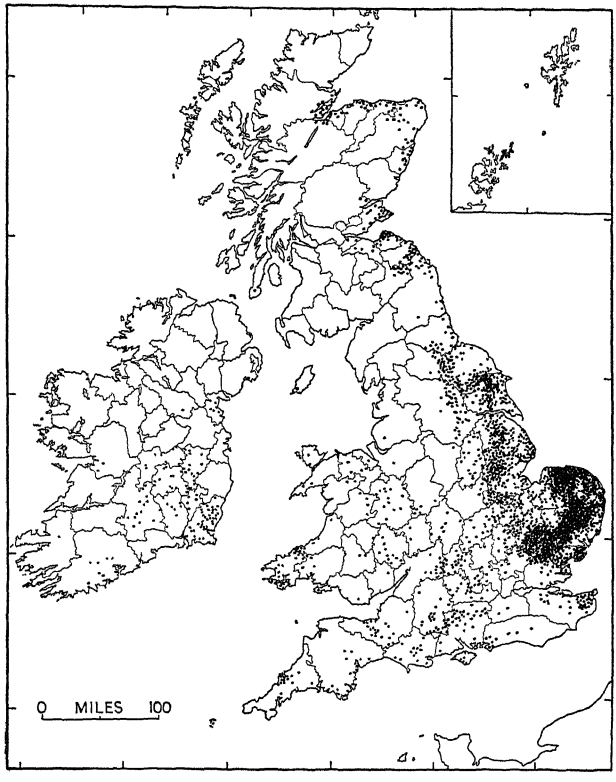

FIG. 102.—Map showing the distribution of barley cultivation in the British Isles

Each dot represents 500 acres in 1931 (Ireland, 1930). The reasons for the choice of this year is the same as for wheat

barley cultivation, given sufficiently dry conditions, is not reached in the British Isles. Barley is not grown primarily as a human foodstuff: about half is malting barley and is taken by the maltsters and the breweries. All kinds of beer, to which reference will be made

[1] But in this country barley is spring sown and wheat is winter sown; therefore it is only where the winter is mild that the wheat will survive. Spring wheats give too low a yield (20 to 25 bushels per acre) to be economical in this country where winter wheats yield 30 to 40 bushels. So far attempts to find a good winter-sown barley have not been successful.

below, have barley as their basis; whilst in Scotland the distillation of whisky from barley is, of course, an important industry. As the table given on p. 183 shows, the yields per acre of barley are again good as in the case of wheat. In 1939–1948 the average yield of barley in England was 17·6 cwt. as against 14·6 cwt. in Wales.

Oats.—Oats are much more widely grown in the British Isles than either wheat or barley. Actually the *optimum* conditions for

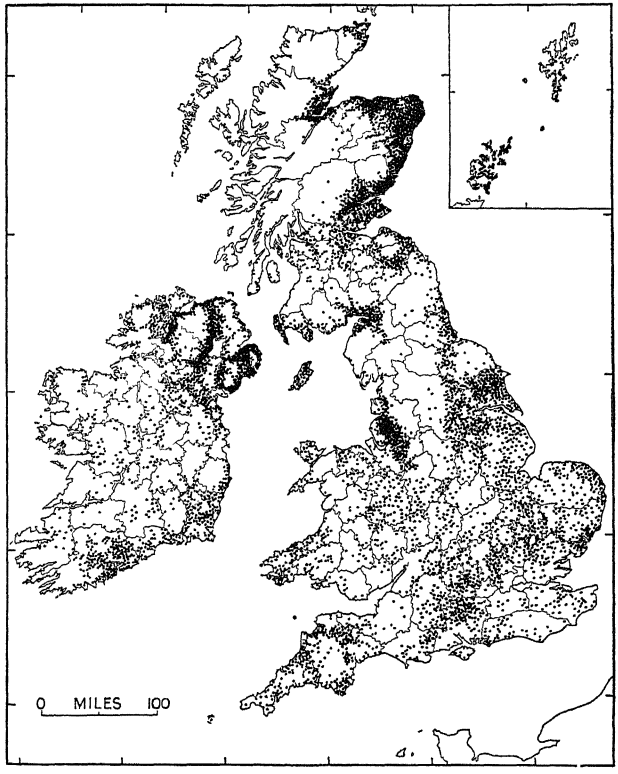

FIG. 103.—Map showing the distribution of oat cultivation in the British Isles
Each dot represents 500 acres

oat cultivation closely resemble those for wheat, but oats *will* grow and ripen under conditions of much greater dampness, and hence of all the grain crops it is the one most eminently suited for the climatic conditions of Ireland, the west of England, Wales, and Scotland.[1] If one studies a map showing the distribution of acreage

[1] Winter-sown oats are usual in the north, spring sown in the south. One reason why oat crops tolerate more moisture than wheat or barley is that the crop is cut before it is dead ripe and there is no need to wait as long at harvest time before cutting as is necessary for wheat and especially for barley.

under oats in the British Isles one notices again a concentration on the eastern dry sides of both islands, especially for example in East Anglia; but here oats are in direct competition with both wheat and barley, and so if one takes the proportion of arable land in each of the counties occupied by oats one finds that this crop is grown least in proportion to the total arable area in the eastern counties from Lincolnshire southwards, and most in proportion to the total arable acreage in western counties. Thus over 30 per cent. of the total tillage (crops and fallow) area in Cumberland (60 per cent.), Westmorland (57 per cent.), Lancashire (43 per cent.), and Cheshire (35 per cent.) was, according to the figures of 1949, occupied by oats. In the Welsh counties as a whole the proportion is over 40 per cent. In Scotland oats occupy more than 50 per cent. of the total tillage area; thus this cereal plays a far greater relative part in the agricultural economy of Scotland than it does in either England or Wales. Indeed, the map of the distribution of oats in Scotland is almost a map of the distribution of human settlements. Similarly of all grains, oats are best suited to the climatic conditions prevalent in Ireland. Under the bright sunny conditions favoured by barley, oats do not flourish and so, for example, are scarcely grown at all in the Mediterranean countries of Europe. It is a very interesting commentary on the climatic conditions of Ireland that no area is too sunny or too dry.

In Scotland it has been estimated that rather more than half the total crop of oats is used for horse fodder and for seed; but a large proportion of the remainder is destined for human consumption. Although amongst town dwellers their popularity in recent years has declined, both porridge and oat-cakes are characteristic articles of diet in Scottish homes. The fine physique of the Scottish highlanders has been attributed—probably with some measure of correctness—to the nutritious value of oats as a food. In England and Wales oats are grown mainly for feeding to live stock, only a very small proportion is intended for human consumption and that mainly in the form of patent foods such as the well known "groats." As the number of horses has steadily decreased less oats are needed for feeding to horses. It should be noticed that oat straw is of great value as animal food, being better for this purpose than the straw from either wheat or barley. In Scotland the average weight of oat straw produced is something like 1½ million tons, though the straw is less abundant than in the case of wheat.

Rye.—Rye is often referred to as the poor relation of wheat. It flourishes under similar conditions but will grow on far poorer soil. It is thus widely grown on the glacial soils of the North European Plain, which are the counterpart of those found in such tracts as central Ireland, and much of Scotland. But except as seed to produce green crops for sheep feed there is little market in Britain

for rye and the acreage was extremely small until the resuscitation of the crop during the Second World War when it was mixed in the "National Loaf." In medieval Britain, rye was quite an important grain, but the British people lost, if they ever had it, the taste for the rather sour though nutritious rye bread so often referred to in this country as "black bread," and which is familiar to all visitors to Germany and to eastern Europe. In America rye bread (actually bread flavoured with rye) is popular. The acreage in Britain jumped from 17,000 in 1938 to 129,000 in 1943, in addition to that grown as green fodder. It is grown mainly on areas of very light soil. Some of the home-grown Irish rye is used in the distillation of rye whisky.

Beans and Peas.—Beans and peas, when allowed to ripen, were formerly included as corn crops, but now a distinction is made between beans and peas grown for fodder and those grown as vegetables. Beans are a heavy land crop and peas a light land crop, but as fodder both have decreased so much in popularity as to be unimportant.

Mixed Corn.—The growing of mixed corn crops was of comparatively little importance in the British Isles except in a few counties, such as Cornwall, where barley and oats (dredge) have been grown together especially since 1918 and provide fodder for livestock. They can be cut green if necessary and the yield as grain is usually higher than for either of the two grains separately. This helps to explain the recent popularity, the acreage in the United Kingdom rising from 95,000 in 1938 to 838,000 in 1950.

Potatoes.—The distribution of potato cultivation in the British Isles affords the most interesting example of the interaction of geographic and economic factors. In the first place, potatoes are grown for food, either for animals or for human beings. There is not that important production for purposes of distillation of industrial alcohol that one finds on the Continent of Europe, particularly in Germany. Secondly, potatoes play entirely different rôles in the agricultural economy of Ireland on the one hand, and of the greater part of England, Wales, and Scotland on the other. The peculiar suitability of potatoes to the humid soil and atmospheric conditions of Ireland was not appreciated until about a hundred and fifty years ago. Prior to that oats, wheat, and barley were the staples. It is not too much to say that the increased cultivation of potatoes rendered possible an increase of population, and perhaps actually occasioned the over population of rural districts prior to the terrible famines of the 'forties of last century. The acreage and production actually reached a maximum in 1859 when in the area which is now the Irish Republic there were 923,054 acres under potatoes. In the decade 1847–1856 potatoes occupied 19 per cent. of the land devoted to crops; in 1930 the percentage

had risen to nearly 24. The annual production of potatoes in Ireland averages over 2,000,000 tons—equivalent to about 14 cwt. per head of population. Allowing for a half fed to stock and 15 per cent. kept as seed, the Irish "eat" or consume about a quarter of a ton of potatoes per head per year. Actually large quantities are prepared and cooked in country households, but only a proportion actually eaten, the rest being fed to pigs and other live stock. In Scotland, as a food crop to supply local needs, potatoes are grown all over the country, but they play an especially important part in the Shetlands, the Western Isles and in the Highlands as a whole. They are grown irrespective of favourable soil or climate, and thus in these parts of Scotland —the more remote areas— potatoes occupy a position similar to that which they do in Ireland. There are certain areas in Scotland where potatoes are grown as a main crop or where special attention is given to raising potatoes as an early crop or as seed. The eastern parts of the Central Lowlands are particularly favourable—especially on the rich deep loams. The main areas for the production of early potatoes in Scotland are situated to the south-west, that is on the side of the country which is the warmer in winter, and of special important is Ayrshire. Close proximity to the sea permits sowing as early as February and the crop is lifted, largely by Irish labour imported temporarily for the purpose, towards the end of June or early in July. Here the soil is light and sandy and has to be enriched by heavy manuring. Markets for these early potatoes of Ayrshire and for the main later crop of the eastern part of the Central Lowlands are, of course, near at hand in the densely populated parts of the Central Lowlands, but there is still a surplus available for sending southwards to England. Both from the point of view of the character of the crop itself and from the relatively low value per bulk, potatoes enter but little into international trade. Whereas in the British Isles as a whole the larger proportion of the wheat which is required is imported, the potatoes consumed in Britain are in the main home pro-

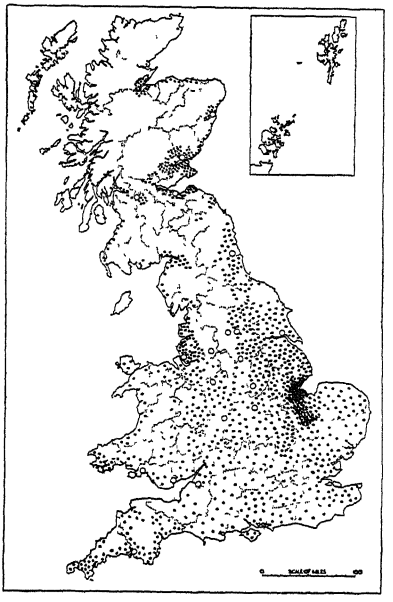

FIG. 104.—The war-time cultivation of potatoes in Britain

duce. Imports are small and consist mainly of new potatoes sold at high prices before the earlier varieties of home-grown potatoes are ready. In England and Wales again potatoes are widely grown for local consumption, but there is a remarkable concentration of cultivation in two or three areas. Two factors are paramount. The first is the suitability of soil—deep, rich, loamy soil being the best and especially one free from stones which interfere with the free growth of the tubers. Secondly, there must be the ready accessibility to adequate means of transport for this bulky commodity direct to the main centres of consumption The first great area of cultivation is that on the fine rich soils surrounding the Wash. In the Holland district of Lincolnshire potatoes occupied in the years 1945–1950 more than a quarter of the total arable area. This is a romance of the last eighty years. The silt lands were formerly cattle pastures, but perseverance with disease and rot-resisting varieties of potatoes rewarded the efforts of a local potato buyer and a local farmer. In the neighbouring Isle of Ely and other parts of Fenland the area is also large. The potatoes from this area are destined very largely for the London market. They are sent directly southwards by rail, and we find in London the great potato markets situated near the northern railway termini (see Chapter XXVII). The second great area is that of the Lancastrian Plain in Lancashire and Cheshire where potatoes occupied respectively 20 and 15 per cent. of the tillage area in 1949. Here the potatoes are grown on the loamy glacial soils of the lowlands and are destined, of course, to supply the great industrial towns of Lancashire. On the fertile drift soils of the southern part of Durham there is an important production for the industrial north-east. The moderate production in the West Riding and in Staffordshire again reflects the requirements of local industrial centres. London naturally encourages the growing of potatoes in Middlesex, Surrey, and Kent. Special mention must be made of the important movement of early potatoes from Cornwall—these being on the market before there are any available from any other parts of the country. In potato cultivation a distinction is drawn between first earlies, second earlies, and main crop. The earlier on the market the more valuable. In Lancashire only about a fifth are first earlies, in Cheshire a half, in Cornwall, two-thirds. Still earlier supplies are of course available from the Channel Islands and the island of Jersey devotes itself very largely to potato cultivation. Taking the United Kingdom as a whole, the acreage under potatoes jumped from 733,000 in 1938 to a peak of 1,548,000 in 1948 and the yield from 5,115,000 to 11,798,000 tons. It should be noticed, especially in England, that in addition to these amounts, which are obtained from the agricultural returns, potatoes are largely grown in gardens and on allotments. It is, indeed, assumed that in England and Wales one half

of the allotment area is planted with potatoes, giving an estimated production of an additional half million tons.

Turnips and Swedes.—The principal root crops grown for animal fodder in this country are turnips, swedes, and mangolds; but a small proportion of the turnips are used for human consumption and these will be considered separately under vegetables. In general, these root crops demand conditions similar to those necessitated by potatoes—good, deep soil free from stones, otherwise the roots cannot form freely. They are, however, largely grown as winter feed for sheep and, to a less extent, for cattle; and it is often possible to correlate a reduction in the acreage, especially under turnips and swedes, with the reduced sheep population of the same areas. As winter feed for stock the crop plays a vital part in British agriculture and is also an essential element in the rotation of crops. The yield is liable to fluctuations from year to year as in the case of all root crops, but over a wide area the variations are not apparent, and in the United Kingdom as a whole the yield ranged only between 12·8 and 15·4 in the years 1938 to 1950. The crop is widespread, but the greatest density is in the east, especially in the north-east where, however, growth is often checked by early autumn frost. In England and Wales there has been a steady decline in the area under turnips and swedes. In 1880 the crop occupied 11 per cent. of the arable area of the country. In the census year of 1925, the area so occupied was only 7½ per cent.; in 1950 it was only 3 per cent. In Scotland and especially in Ireland the crop remains more popular.

Mangolds.—It is extremely interesting to compare the distribution of mangolds with the distribution of turnips and swedes. They form, of course, the other great root crop. In the first place the acreage under mangolds in Scotland is negligible. The summer is too short, the crop too susceptible to frost for there to be any extensive cultivation north of the English border. On the other hand, in England, especially in the drier and warmer south, mangolds grow well and in those areas are definitely superior to turnips and swedes. In the first place the yield per acre is considerably higher. The average for the whole of England and Wales ranges between 16 and nearly 24 tons per acre (1941–1950) and it reaches from 25 to 30 tons per acre in the rich soils surrounding the Wash, in the Holland district of Lincoln and in the Isle of Ely. Although the actual acreage under mangolds has changed little in England and Wales from 1880 to 1930, with the general decrease in the total area of arable land, this represents a fairly general increase relatively to the arable land, and illustrates the increasing popularity of mangolds and their superiority over other root crops.

Sugar Beet.—The cultivation of sugar beet in the British Isles is a development which took place after the First World War.

The major controls involved in determining the distribution of cultivation are geographic, the local are economic. Questions of soil and climate tend to limit sugar beet cultivation to areas of good, deep, well-drained soil where there is not excessive moisture. Thus there is a concentration of cultivation in East Anglia. In Scotland the good friable soils of Fifeshire are of the greatest importance. The economic considerations are closely bound up with transport costs. The beet is heavy and usually transport costs limit the area from which any given sugar factory can draw its raw material. This factor will be considered in the special section on beet sugar production given below.

Miscellaneous Fodder Crops.—Although in the aggregate miscellaneous fodder crops occupy quite a large area the main cause for surprise is that when compared with the staples they are insignificant. The area which they occupy in the United Kingdom as a whole is under half a million acres. The chief are rape, cabbage, kale, savoy, kohl rabi, vetches or tares, fodder mustard, and lucerne. Lucerne is particularly popular in the south-eastern counties—in Essex, Kent, Norfolk, and Suffolk. In Scotland rape is the most popular crop. Two things strike one about these miscellaneous fodder crops in the British Isles. The first is the almost complete absence of maize grown as a green fodder crop. Birds steal the seeds, growth is very poor in dry seasons, autumn frosts do great damage. Similarly, it is rather surprising to find lucerne occupying such an insignificant position in this country; though it is now tending to increase, it has a strong rival—better under some conditions—in clover. Those farmers who have been very successful with lucerne say that their compatriots will rarely take the special care which is needed.

Clover and Rotation Grasses.—In those parts of the British Isles where a five-year rotation is practised it is obvious that an average of 20 per cent. of the arable area ought to be returned as under clover or sown grasses. Most of the lowland counties of England do approximate to this percentage; it is indeed below this figure in the eastern counties and very much below in the area immediately surrounding the Wash, but rather above it in the Midland counties. On the other hand, in the western counties of England and Wales the proportion is greater. In Cornwall it reaches actually more than 50 per cent., and it suggests therefore that land which is sown to grass in that county is left unploughed for at least three or four years. Similarly in Scotland, there is a marked difference in practice between the east and west. In the west, for which Ayrshire may be quoted as an example, it is quite a common practice to leave land down under grass for ten or even fifteen years and then to plough it for two. Even in the east sown grass for one year out of five is rather the exception than the rule. One result of this is the

large proportion of grassland which is recorded in Scotland as rotation grassland; it exceeds in acreage the permanent grass. The Scottish farmer improving ordinary rough hill grazing prefers to convert it to arable land rather than to lay it down under permanent pasture. Clover and rotation grass may, of course, be used as fodder by turning the cattle or sheep on to the fields themselves; in other cases it is cut as green fodder, but a considerable proportion of sown grass is cut for hay. In Scotland rather over a quarter is so used, in England and Wales something like two-thirds of the total area is cut for hay. It reaches as much as 80 or 90 per cent. in the eastern counties. Hay made from sown grasses is usually distinguished as seeds hay in contrast to meadow hay made from permanent grassland. Special mention should be made of the timothy meadows which occupy considerable areas in certain parts of Scotland, particularly in northern Ayrshire and the adjoining parts of Lanarkshire and in the Carse of Stirling. Timothy grass favours heavy clay soil where the yield of other green crops is uncertain. Under the stimulus of war time improvements the yield of hay from temporary grassland did not drop below 26 cwt. per acre in the decade 1941–1950 and reached 29·9 cwt. in 1949. However, much of the nutriment in the grass is lost when it is made into hay; dried grass is much better but the fuel costs in drying are high; silage is excellent feed but silos are expensive to construct. The solution may lie in silage kept in simple earth trenches which can be dug by any farmer.

Flax.—Flax can be grown either for fibre or for seed, and it is rarely that the plant can be made to yield both, since flax required for fibre has to be pulled before the seeds are ripe. The growing of flax for fibre, once important in England, became almost entirely restricted to Northern Ireland until war-time needs brought back cultivation in many parts of England in 1941–1945. Flax requires a very well drained, clean, heavy soil. The seeds are planted closely together, since the closer together the plants can be made to grow, the finer the stems and the better the fibre. The plants require constant attention—such as hand weeding. Flax is usually grown in a seven-year rotation with other crops. Soil and a suitable labour supply are really more important than climate. Cultivation is now most important on the heavy basaltic soils of the lower Bann valley, and to the west of Lough Neagh, and especially in the valley of the Main to the north of the Lough. In England during the temporary resuscitation of flax growing for fibre in the years 1918 and 1919, the crop occupied 11,000 acres. But as early as 1925 the area had sunk to just under 700 acres—mainly in Somerset and Yorkshire. Flax is grown for linseed in England and Wales, over rather larger areas, particularly in the eastern counties and the acreage actually reached 86,000 acres in 1948, compared with 14,000 for flax.

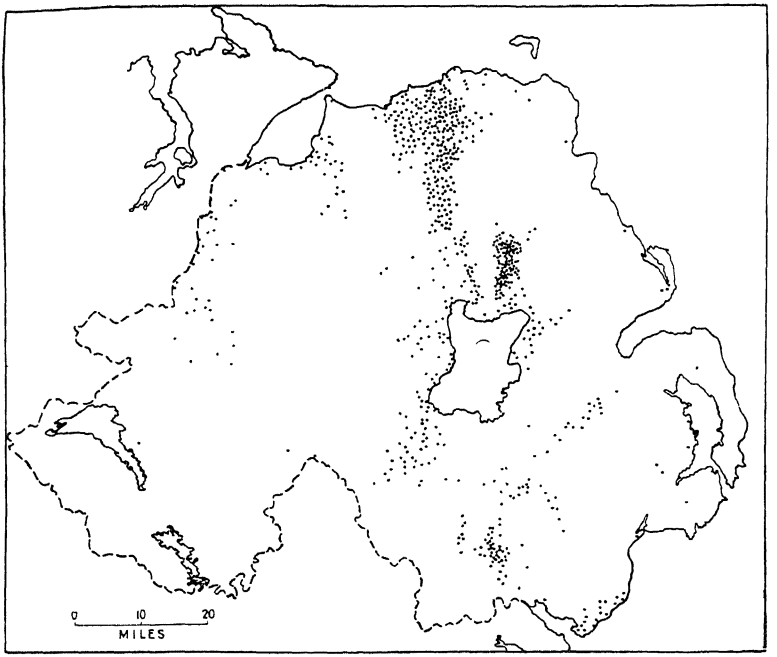

FIG. 105.—Map showing the distribution of flax in Northern Ireland

Each dot represents 25 acres in 1928. The distribution in 1946–1950 has been similar

Hops.—In recent years about 20,000 acres have been occupied by this crop. Considerably more than half is in Kent—on the northern slopes of the Downs and in the Weald. The other centre of cultivation is the county of Hereford and the neighbouring parts of Worcester and Shropshire. Over most of the remainder of the British Isles there is really no hop cultivation. The old expensive method of providing hop poles has now largely been replaced by a permanent or semi-permanent arrangement of heavier poles with wires. But the great problem of the hop industry is the labour requirement at the time of harvest. In the Kentish area, this labour is derived from London, and for periods of a fortnight or three weeks large numbers of East End workers are brought down for what is to them and their families an annual country holiday. Hops are required, of course, to give the bitter flavour to beer. The oast-houses in which hops were dried and stored are still familiar features in south-eastern England. Many of them are disused now that there is a centralisation in the collection and marketing of hops.

Vegetables grown for Human Consumption.—In recent years

the increasing acreage under market garden crops has been very marked, as the following table shows:

ENGLAND AND WALES

Crop	Acreage 1922–30	Production 1925 census	Acreage 1939–1948	Production 1939–1948
		Tons		Tons
Green peas	48,675[1]	72,700	71,300	151,000
Beans, broad and runner	12,782[1]	33,900	16,900	58,000
Cabbage for human consumption	26,784	410,000	90,700	702,000
Brussels sprouts	22,876	93,000	40,300	130,000
Cauliflower and broccoli	12,504	162,000	39,200	229,000
Carrots	9,935	110,000	31,100	333,000
Turnips for human consumption and swedes		100,000	19,800	191,000
Onions	2,276	17,100	11,900	84,000
Celery	5,581	37,300	5,900	67,000
Rhubarb	6,522	60,300	6,900	63,000
Beetroots	—	—	11,300	100,000
Parsnips	—	—	6,600	62,000
Peas, dry	—	—	103,600	73,000
Asparagus	—	—	1,800	2,000
Leeks	—	—	4,200	3,100
Lettuce	—	—	14,600	82,000
Other vegetables	—	—	27,600	196,000
Glasshouse produce—				
Tomatoes (also in the open)	—	47,000	55,500	113,000
		No.		
Cucumbers	—	50,000,000	—	10,000
		lbs.		
Grapes	—	1,500,000	—	—

[1] 1926–1930.

The industry in the British Isles is one of market gardening rather than that which is known on the other side of the Atlantic as truck farming. The two factors which most strongly influence the distribution of vegetable cultivation are, first of all, the presence of suitable soil, and in this respect good, deep, rich soil, such as we have mentioned in the case of potatoes, is required. Earliness is one of the great qualities in a market garden soil. In the second place transport facilities (or the nearby presence of markets) must be good. Thus there is, or was until the great spread of housing and the establishment of Heathrow airport, a great deal of intensive market gardening in Middlesex for the supply of London's markets. On a larger scale vegetables are grown, particularly in the rich soils of the Fens. For example, nearly a quarter of the total area under turnips is in the small county of the Isle of Ely alone, for the supply of London. Bedfordshire is also an important market gardening county—Sandy has been famous for more than a hundred years—

but a very large proportion of London's vegetables come from the rich belt of mixed soils in northern Kent. The Vale of Evesham serves Birmingham and has a nation wide market for some of its products. The East and West Ridings of Yorkshire play an important part in the supply of vegetables in the northern counties. The influence of climatic conditions has been observed to be of marked importance in recent years in relationship particularly to Cornwall, where many vegetables are ready for market before they are in other areas. There was even developed in the inter-war years an export trade in broccoli. The development of the British canning industry and the still more modern use of quick-freezing should be noted.

Small Fruit.—The bulk of the small fruit grown in England and Wales may be found in three areas. The most important of these areas is Kent, especially on the mixed soils of the fertile northern belt of the county. The fruit growing area also stretches into the neighbouring counties of Sussex, Essex, Middlesex, and Surrey to some small extent. The second is that which lies round the Wash and which includes parts of Norfolk, Cambridge, the Isle of Ely, and the Holland district of Lincoln, and has an important centre at Wisbech. The first of these areas has about a quarter of the total acreage for England and Wales, the second about a third. The third tract is the county of Worcester together with neighbouring parts of Gloucester and Hereford. Hampshire has, in addition, important areas devoted mainly to strawberries, whilst Devon and Cornwall have also important acreages. Some 40 per cent. of the area devoted to small fruit is under strawberries, another 40 per cent. under currants and gooseberries, leaving only 20 per cent. for raspberries and the remainder. In Scotland there is similarly a concentration of small fruit cultivation. By far the most famous area is, of course, the Carse of Gowrie with its suitable soils, its comparatively low rainfall, its sunshine and its southern aspect. The great difficulty in the British Isles with regard to the cultivation of small

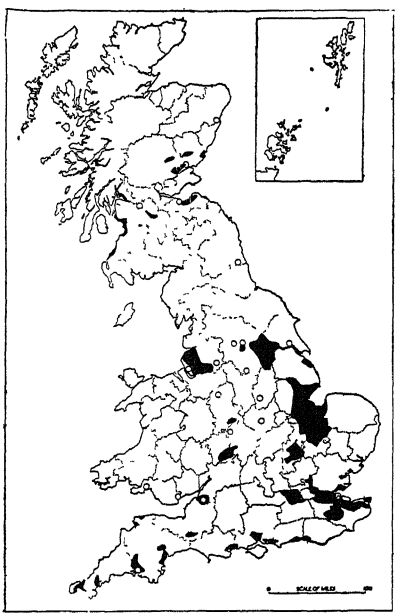

FIG. 106.—The main market gardening and fruit farming districts of Britain

fruit is the short ripening period in the summer; in other words, the markets are suddenly glutted for about a fortnight with each type of fruit, when there is suddenly a supply in considerable excess of the demand. This is where jam making, canning and deep-freezing are important.

Orchards.—Orchards are of negligible importance in both Scotland and Ireland. Apart from the quite considerable production of orchard fruits from isolated trees in gardens, regular orchards probably include about 25,000,000 trees in England and Wales occupying 268,000 acres (1949). Sixty per cent. of these are apples, plums come next with 30 per cent., pears about 8 per cent., cherries and all others forming the remainder. In England and Wales three groups of counties contain the bulk of the orchards. Kent, again the fertile northern stretch, leads with 75,000 acres (1949), Worcester, Hereford, and Gloucester come next with almost as many, then followed by Devon and Somerset. These three areas have two-thirds of all the fruit orchards in the country. Included under "other fruit trees" are nut trees. The average yield of orchard fruit is far more variable than that of small fruit, and the following table for two recent years illustrates this extraordinarily well. In

AVERAGE YIELD PER TREE OF ORCHARD FRUIT IN 1941 AND 1947

Description	1941	1947
Apples—	lb.	lb.
Dessert and cooking	19·5	85 4
Cider	34·2	107·8
Pears—		
Dessert and cooking	15·3	41·8
Perry	59·1	132·5
Plums	19 8	56·6
Cherries	15·7	71·3

any given orchard there is often an alternation of low and high yields per tree. A large proportion of the apples grown in this country are cider apples. This is particularly the case in the orchards of Herefordshire, Somerset, and Devon, which are the great cider-making counties. In many parts of the country cider takes the place of beer as the natural local drink, and it is widely appreciated all over the country. Perry, a comparable beverage made from pears, is not nearly as widely known, and is more restricted to the west country. For many years it has been the practice in the west country to replace gaps in cider orchards by apple trees of dessert or cooking varieties, so that there has been a tendency for a general reduction in the production of cider apples and a greater production of dessert and cooking apples. In recent years the bulk of trees planted have been of Cox's Orange Pippin—the favourite apple

both for dessert and cooking. The research stations at Long Ashton and at Malling near Maidstone are doing much to foster scientific intensive fruit farming. We have a number of excellent apples of good keeping qualities which can be kept in ordinary cellars until after Christmas, whilst with the extension of proper storage facilities there is no reason at all why excellent dessert apples of home origin should not be available for British markets throughout the year. At the present time extensive experiments are being carried out in storage controlled by low temperature gas. Previously Britain has depended largely on imported apples for the period Christmas to July.

Flowers.—Flowers grown in the open occupy some 20,000 acres, apart from the very large areas under glass. Daffodils, narcissi, tulips and violets occupy large areas, the first three being grown very extensively in the light, friable but rich soils round the Wash and particularly in the Holland district of Lincoln; and it is in the neighbourhood of Spalding that one finds the bulb farms rivalling the much advertised farms of Holland—not only rivalling them in size, but certainly in quality of products. It is an interesting pilgrimage for the motorist to visit one of our own bulb farms in this area. An interesting development of the industry is that in Cornwall (including the Scilly Isles) where, owing to the mildness of the winter, flowers for the London market can be produced as early as January, and the trade is at its height from January to April.

Glasshouse Products.—In 1949 commercial glasshouses in England and Wales covered 4,766 acres. The home counties in a ring round London account for more than a third of the glasshouses and of course supply largely the London markets. The western side of the Lea Valley between Ponder's End and Broxbourne, centring in Cheshunt and Waltham Cross in Hertfordshire, is probably the most intensively cultivated area in the world, with a thousand acres under glass. Tomatoes are by far the most important crop. Other glasshouse crops include cucumber, grapes and other fruit and vegetables, with a large variety of flowers and plants.

The Distribution of Live Stock in the British Isles

Horses.—It is a matter of greatest difficulty to get a correct view of the distribution and importance of the horse in the British Isles at the present day. The published statistics are misleading in that they refer to horses on agricultural holdings, and are based on returns made by farmers. Taking first the horses recorded in this way, there has, as one might expect, been a steady annual decrease in recent years, which cumulatively over the post-war years has been really very rapid. In 1921 there were recorded on farms 1,384,587 in England and Wales, 216,621 in Scotland and 100,400 in Northern Ireland. Ten years later, in 1931, the numbers had fallen to

938,494 in England and Wales, 152,668 in Scotland, and 86,486 in Northern Ireland. The horses on agricultural holdings are divided into three classes: horses used for agricultural purposes, including mares kept for breeding, unbroken horses—that is mainly young stock—and other horses which are saddle and carriage horses and vanners. In 1950 the total on agricultural holdings in Great Britain had fallen to 494,000 and in Northern Ireland to 35,000—only half the numbers of 1940. Turning to horses other than those used on farms, similar declines are, of course, noticeable, though it is difficult to get actual statistics. Standing rather by itself is the breeding of horses as hunters, race-horses and others for pleasure purposes, and with this the production of bloodstock for export. In this industry Britain is still supplied to a considerable extent from the well-known race-horse breeding industry of the Irish Republic, particularly in the hinterland of Dublin in Kildare. In Britain as a whole the location of breeding establishments is determined by proximity to well-known racecourses. Thus there are such centres of breeding as Epsom, Newmarket and Lambourn where the existence of downland suitable for exercising horses has obviously had an important influence.

The decrease in number of agricultural horses is, of course, closely connected with the growth of mechanisation. Elaborate statistics are now published of agricultural machinery. So rapid is the change over that in the two years 1946 to 1948 small tractors alone increased by 60 per cent. By the January 1948 census, there were 230,000 tractors in England and Wales alone. In general terms nearly every full-time farmer now uses a tractor.

Cattle.—In the year 1931 there were nearly 12,000,000 cattle in the British Isles; of these 6,065,000 were in England and Wales, 1,109,000 in Scotland, and the remainder in Ireland. In 1950 there were 10,620,000 in the United Kingdom of which approximately 8,000,000 were in England and Wales with 4,322,000 in the Irish Republic; the total in the British Isles in 1950 was thus nearly 15,000,000. There is a broad distinction into dairy cattle and beef cattle. About one third of the total animals in England and Wales are heifers and cows in milk; the proportion in the United Kingdom is rather less, but clearly dairy animals now greatly outnumber beef animals. It is scarcely necessary to remind ourselves of the growth of cattle—both dairy farming and beef production—at the expense of crop farming. The table given opposite (which refers to England and Wales) brings out several interesting points. Although the number of cattle has increased more or less steadily from 1867 onwards, that is from the date of the first agricultural statistical record, both actually and in relation to the total cultivated area,[1]

[1] The increase is partly due to the fact that cattle are now killed younger than previously.

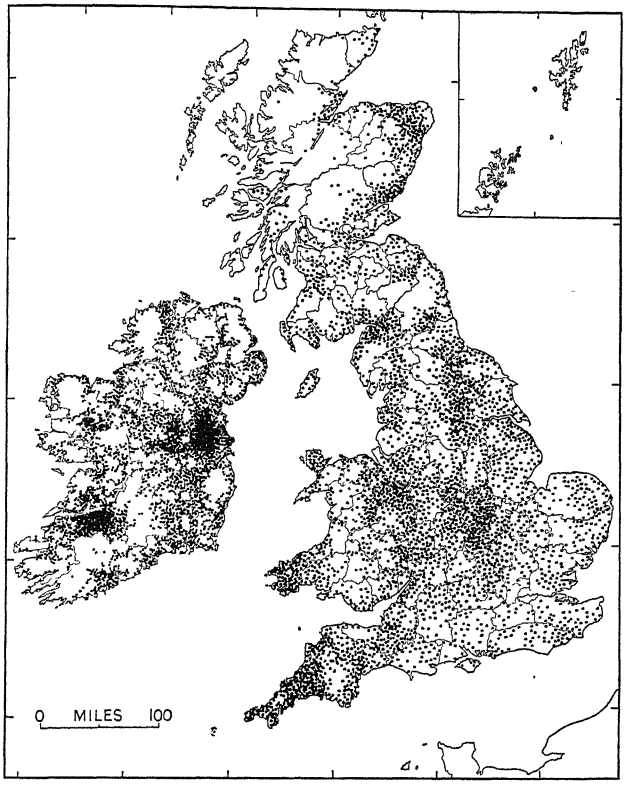

FIG. 107.—Map showing the distribution of beef-cattle in the British Isles
Each dot represents 1,000 animals

	Nos. of cattle per 1,000 acres of land under cultivation			Nos. of cattle per 1,000 of population		
	Cows and heifers in milk or in calf	Other cattle	Total	Cows and heifers in milk or in calf	Other cattle	Total
1867–76 . .	68	104	172	78	119	197
1877–86 . .	70	109	179	74	115	188
1887–96 . .	76	115	191	72	110	181
1897–06 . .	80	122	201	67	102	169
1907–14 (8 yrs.)	86	127	213	66	96	162
1915–24 . .	95	129	224	69	94	163
1925	105	134	239	70	89	158
1939	90	170	280	—	—	—
1945	94	216	310	56	122	178
1950	104	237	341	63	149	212

the increase has failed to keep pace with the growth of population. This is offset to some extent by the increasing yield of milk from dairy cows and the increase in the quality of the beef cattle, but in the main it resulted in the increased dependence of this country on imports of beef and dairy products and latterly on a decrease of meat in our diet. The rearing of cattle is an industry for which the climatic conditions of this country with its open winters and its good growth of grass is pre-eminently suited, and one therefore deserving of encouragement in all directions. We will now consider separately the distribution in space of dairy cattle and beef cattle; for although in some areas cattle are dual purpose animals, the females being for the production of milk and the males for the production of meat, there is on the whole a very marked contrast in the distribution of the two types. Both dairy cattle and beef cattle require good pastures and good fodder; but apart from this there is considerable divergence.

Dairy Cattle.—Dairy cows must be milked night and morning. Tracts of pasture difficult of easy approach to the farm because of intervening tracts of moorland, bog, or mountain are of little use; thus we find for the successful keeping of dairy herds, the pastures themselves must be readily accessible from farmhouses. In the second place the utilisation of the milk depends very largely again on questions of accessibility.

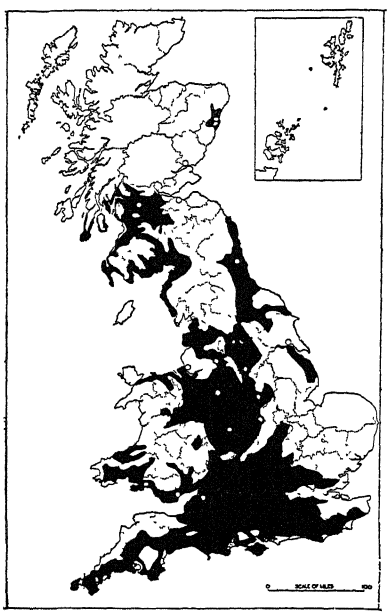

FIG. 108.—Map showing the main dairy-farming areas in Great Britain

Where the farm is accessible to good road or rail transport, and is within reasonable compass of great consuming urban centres, then it is probable that the milk will be sold as such. Where the farming areas are more remote, but when the farms are still comparatively accessible from one another, it is likely that the co-operative production of butter will result, or, in certain areas where the tradition has been established, cheese. In the butter-producing areas, there is the utilisation of the skimmed milk to be considered, and it is in such tracts that a subsidiary pig-rearing industry will tend to grow up. These general principles are well illustrated by establishing a contrast between

the Irish Republic on the one hand and England and Wales on the other.

Britain with its vast industrial population needs huge quantities of milk which is more conveniently produced at home than imported. The value of milk as a food especially for children led to a concentration of war-time effort in 1939–1945 on increasing production. Consumption rose from 169 pints per head pre-war to 237 in 1944 under priority rationing to mothers and children. Not much is left for conversion to butter or cheese, but these are commodities more easily imported. As a result of the huge demand for milk dairying has spread to the greater part of lowland Britain as the dominant farming enterprise. The home counties and those as far west as Wiltshire and Somerset are sufficiently accessible to send their daily supplies of milk to London, and here another point arises. Economic considerations of the nearness of the consuming centres may cause it to be a paying proposition to keep dairy cattle under conditions which would otherwise be unsuitable. Thus one of the driest English counties and one which would not be expected, therefore, to be so suitable for dairy farming, despite its wet clay soils, is Essex. But Essex has become quite an important dairying county because of its proximity to the great consuming centre of London.

In England the rich lowland pastures of such areas as Cheshire, northern Wiltshire and Somerset are the most suitable. In Scotland one notices the concentration on dairy cattle in the northern part of Ayrshire and around such consuming centres as Glasgow and the other industrial areas in the central lowlands. Except around towns (see Fig. 115), dairy cattle become comparatively unimportant as one goes northwards owing obviously to the increasing difficulties of access. The very fertile stretch of lowland lying to the south of the Southern Uplands from Wigtownshire through Galloway also stands out. From this area milk can be sent to the Central Lowlands and also directly to the industrial areas of the north-east of England, such as Newcastle, and even to London.

A good dairy cow in milk will yield 1,000 gallons a year, but the average is much lower—500 to 700 gallons. There is a danger of sacrificing quality for quantity and a very high yield may result in milk so low in butter fats as to fail to reach standards laid down by the Milk Marketing Board. About half the dairy cows in Britain are shorthorns and they are widely distributed. The other dairy breeds are much more localised in their distribution, though the localisation depends more on farmers' preferences, than on geographical conditions. The small Jersey cow, with a modest yield of very rich milk is, however, largely restricted to the warmer south; the larger Guernsey is more widespread. The Ayrshire is a Scottish favourite, the black and white British Friesian is much favoured in the Midlands and east of England.

Other Cattle.—One of the most striking features in the figures over the past fifty years, relating to cattle other than dairy cows, is the relative increase in the number of young stock of under two years. Cattle of two years and upwards may be assumed to be almost entirely for beef production, and below that age the animals may be either destined for the dairy herd or for the slaughter-house. It proved economical to breed animals which matured quickly, and would be killed as "baby beef." Thus an increased proportion of beef is obtained from young animals, which, although under two years of age on June 4 in each year when they are enumerated, are slaughtered for beef before the next June 4 comes round. Turning now to the map (Fig. 107), showing the distribution of cattle other than dairy cattle in the British Isles, in England and Wales one notices first of all the concentration in the Midland counties where there is a large proportion of good rich pasture, the famous fattening area. But if one studies the distribution of cattle on rather a different basis, namely that of a thousand acres of crop land and grassland, one finds the predominance of cattle in the wet western counties, such as the mountainous counties of Wales as well as the hilly areas of Devon and Cornwall, and Cumberland, whilst the lowest proportions are reached in the East Anglian counties, as one might expect. In Scotland the map shows the interesting contrast compared with that of dairy cattle. There is no longer a concentration round the towns of the Midland Valley, but as one goes northwards, particularly in the great Buchan Plateau of Aberdeenshire and around the Moray Firth and farther northwards, beef cattle become much more important than dairy cattle. What does strike one about the maps is the comparative absence, in fact one might say almost complete absence, of cattle over the main areas of the Highlands of Scotland. It is to be feared that the picturesque "Highland cattle," beloved of the artist, are conspicuous by their absence and tend to be found only in certain low-lying glens. As we shall see later, sheep are the animals of the Highlands themselves. Turning to Ireland, it would be difficult to find a more conclusive proof of the different conditions required by beef cattle compared with dairy cows. The enormous number living on the Central Plain is the outstanding feature, and particularly the great number in the almost immediate hinterland of Dublin. One can almost imagine them waiting there to be exported in normal times to Britain for fattening and for slaughter. Naturally there are large numbers of beef cattle in the dairying regions also, but both types avoid the main mountain areas and the tracts of bogland.

As with dairy cattle, there are marked differences in distribution of the various breeds. Beef shorthorns are widespread. The black Aberdeen Angus is the favourite in Scotland; the white-faced Hereford in and around the county from which it takes its name; the

Welsh black in Wales; the dual purpose Red Devons in the south-west. All breeds may be seen on the fattening pastures of Leicestershire.

Sheep.—The British Isles have long been famous for their sheep. Not only was wool a staple product and export in the Middle Ages, but at a later stage British sheep became famous for their meat. Most of the British breeds are heavy animals, producing good, well-flavoured meat, and at the same time having a heavy fleece

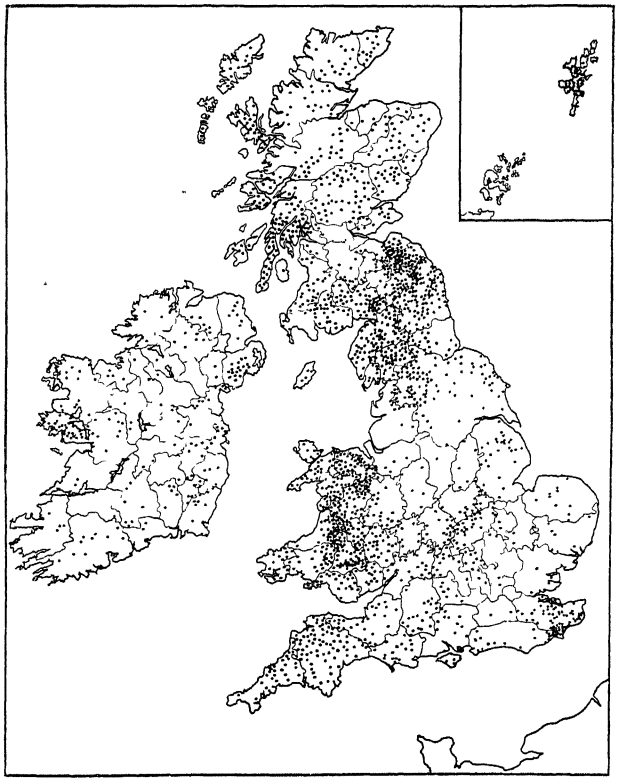

FIG. 109.—Map showing the distribution of sheep in the British Isles
Each dot represents 10,000 animals. Total in the United Kingdom 20,000,000 in 1950

of excellent quality wool. The large sheep populations of the great grassland countries of the Southern Hemisphere, such as the Argentine, Uruguay, South Africa, Australia, and New Zealand, are very largely of British origin. The only rival indeed of the British breeds is the merino—a wool-producing sheep suitable for arid conditions. The British Isles have still a very large number of sheep. From 1939 to 1945 under war-time conditions sheep had to give place to cattle producing the all-important milk and were deliberately moved away from the richer areas such as Romney Marsh. In the

United Kingdom as a whole the total fell from about 27,000,000 in the nineteen-thirties to 20,000,000 in 1944 and 1945, whilst disastrous winter losses reduced the total still further to 16,700,000 in 1947. Not until 1950 did the numbers reach 20,000,000 again. Of these about rather over 8 million were in England, rather less than 4,000,000 in Wales, leaving some 7,000,000 in Scotland, and three-quarters of a million in Northern Ireland.

These numbers are large. There are normally as many sheep as in the whole of New Zealand and between a quarter and a third of the total in the whole of the Australian continent. When one remembers the dominantly damp character of the climate of the British Isles these few figures ought immediately to do away with the fallacy that sheep cannot thrive under damp conditions. The actual facts are that the amount of rainfall or moisture is more or less immaterial provided the drainage is good. It is in waterlogged, low-lying pastures that sheep give place to cattle, and where, if an attempt is made to keep them, they suffer from diseases of the feet as well as an unsuitable diet. Sheep are the animals of the moor and hill pastures, and of the short wiry grass of the limestone hills, though they enter into the economy of a large number of mixed or general farms. These facts are well borne out in general by a study of the map. In England and Wales there is a large sheep population on the hill pastures of Wales, in the Lake District and on the Pennines. They are obviously numerous on the limestone pastures of the south-east. There are areas, however, where sheep are important despite the fact that one would not expect them to be. This is particularly the case in the flat drained marshland of the Romney Marshes in Kent, where the Romney sheep are especially famous.[1] In Scotland the huge numbers of sheep on the upland pastures of the Southern Uplands is particularly noteworthy, more especially in the drier eastern regions in the Tweed Basin. In the Central Lowlands sheep are not numerous on the low-lying ground, but are by far the most important animals on the hill pastures of that line of volcanic hills which runs across the Midland Valley parallel to the Highland boundary fault. Then the map shows at once the great importance of sheep throughout most of the Highlands or Scotland, including, it will be noticed, the western islands. An extensive migration of sheep takes place in most of the larger sheep-rearing districts. An excellent example is afforded by Cumberland, where the sheep are kept up on the hill sides (or "fells") in the summer months, but in winter are driven to the pastures of Solway Plain. The same migration is found in the Welsh region as well as in the Highlands of Scotland and in many other tracts. There are obviously two factors in operation. One is

[1] But the corresponding Pevensey marshes are devoted to cattle, largely because running water for drinking purposes is available.

climate. The mountain pastures are cold, bleak, and often snow-covered in winter; but far more important is the character of the pastures themselves, which actually provide food only in the summer months. Important studies have been made in recent decades by the Welsh Plant Breeding establishment at Aberystwyth under the guidance of Sir George Stapledon.[1] He has pointed out that, after the Napoleonic Wars, isolated but well chosen areas in narrow fields were ploughed for oats on the Welsh Hills up to 1,500 or even 1,700 feet, and that these areas can still be distinguished in that they afford better pasture than the surrounding rough pasture. It is

[Photo: L. D. Stamp

FIG. 110.—*Nardus* grassland—rough hill pasture capable of extensive improvement by burning and seeding
Experimental Farm, near Devil's Bridge, Wales

clear from these patches, with their comparative abundance of *Agrostis* rather than moorland grasses, and the occurrence of white clover and such weeds of cultivation as hawksweed, that the surrounding areas of pasture might in any case be much better than they are. When he made his survey of the hill lands of Wales in the 'thirties, Stapledon found something like 2,000,000 acres of rough hill pastures, about half mainly of grass, of which he considered half favourable from the point of view of aspect and other considerations

[1] "Climate and the Improvement of Hill Land," *Geography*, XVIII, 1933, 17–25; *A Survey of the Agricultural and Waste Lands of Wales*, London, Faber and Faber, 1936; E. Davies, "Sheep-farming in Upland Wales," *Geography*, XX, 1935, 97–111; Compare C. S. Orwin, *The Reclamation of Exmoor Forest*, Oxford University Press, 1929. See also W. Ellison, *Marginal Land in Britain*, London, Bles, 1953.

for improvement. The very wet areas of cotton grass, sphagnum and other types of bog would be expensive to drain, but there remained three types of grass pasture suitable for consideration: (1) *Molinia* or flying-bent pasture; (2) *Nardus* or wet-grass pasture; (3) Bent-fescue (*Agrostis-Festuca*) pasture. The natural defects of these pastures are that *Molinia* is deciduous and is only used by sheep feeding for about one month; *Nardus* is unpalatable to sheep, and whilst the bent and fescue are palatable they are of low feeding value, particularly in that they lack lime. Further disadvantages are the lack of leguminous plants—that is, plants of the pea and bean family—such as white clover, and of herbs such as daisies, which have an excellent feeding value. The need is to introduce wild white clover, and more palatable grasses with a longer growing season. Even by the simple process of cutting off, grazing hard and then manuring, the bent and fescue, *i.e.* the better grasses, are increased in numbers; thus large areas of our hill pastures can easily be improved. The method is to fire, then to prepare the surface by disc-ploughs drawn by tractors, then to manure with basic slags and nitrate chalk, and then to scatter seeds over the surface, especially of wild white clover. Actually the ploughing, manuring, seeding, and rolling can be done in one operation, the necessary implements being drawn by one tractor. It may be necessary to distribute small quantities of soil from lowland regions which is inoculated with the nitrogen-fixing bacteria required for the life of a leguminous plant such as clover. Surface sowing on these hill pastures is possible because of the extreme moisture of the climate. This is an advantage of the climate which otherwise is far from favourable. The main trouble is not the excess of rain, but an excess of misty damp days producing a soggy ground and a humid atmosphere. Stapledon claimed that 10–15 per cent. of the land of the sheep walks might be improved, and by the proper alignment of fences this improved land could be used in such a way that each of the major sheep walks had a proportion of it. He further suggested much also might be done by the planting of trees as shelter belts, so that it would be possible for sheep to be kept out on the fells or hill pastures throughout the year. Heather moorlands can be improved in the same way, by the simple process of burning, since young heather itself has an important nutritive value for sheep feeding. Stapledon considered it would pay also to keep limited numbers of cattle on the hill pastures, not because the cattle themselves could be expected to pay, but they would gradually benefit the ground by their manure.

It should be noticed that the number of sheep in the British Isles fluctuates somewhat considerably from year to year. Weather conditions during the lambing season play a big part in the variation in the total number of sheep. It must be remembered that large numbers of sheep are slaughtered as young animals. Thus, a third

of the total number of animals in Scotland are slaughtered every year; and the annual production of Scottish mutton and lamb is normally of the order of a million cwt. The figures for England and Wales are twice as much. By way of comparison the wool cut averaged in the inter-war years 20 million lb. in Scotland, and 50 million lb. in England and Wales. In addition to this, 6 million lb. was obtained from the carcasses of slaughtered sheep in Scotland and 15 million lb. in England and Wales.

One of the most remarkable features of the sheep-rearing industry

[*Photo: L. D. Stamp*

FIG. 111.—"Fell" sheep in Central Wales

in the British Isles is the local distribution of the main breeds. Thus in Scotland some 60 per cent. of the sheep are the Scottish Blackface, over 25 per cent. are Cheviots, the former predominating on the higher and more exposed districts of the poorer pasturage, the Cheviots on lower ground, especially in the east. In England and Wales, there are the Welsh mountain sheep of the uplands, the Herdwicks of the Lake District, the Lonks and Wensleydales of the northern Pennines and the breeds whose habitat is defined by their names, the Leicester and Lincoln breeds being particularly famous on the drier pastures of the eastern counties, the Southdown sheep on the South Downs, and other Down breeds elsewhere on the chalk, the specially adapted Kent or Romney Marsh sheep on Romney Marsh. These are but a few of the large number of breeds.

Pigs.—By comparison with sheep and cattle, pigs are the smallholder's animal though they may be kept in small numbers around the farmstead by the larger farmer. On the whole the pig population

in England and Wales is most dense in the lowland counties, whilst the smallest numbers are found in the hilliest parts of the sparsely populated counties such as Northumberland, Cumberland, and Westmorland, and in Wales. Pigs can be fed on waste human food and this is often responsible for considerable density near the large towns, as in Middlesex and parts of Scotland. Where butter is extensively made, pigs are largely fed on the skimmed milk thus produced in quantities. With the increase in attention to whole milk there is less connection than formerly between dairying and pig keeping. The total number of pigs, however, in the British Isles is not large and it tends to fluctuate in accordance with the so-called "pig-cycle" between about 1½ and 4½ million in the United Kingdom. Pigs are largely slaughtered for the production of pork and reference will be made later to the difficulties of the bacon industry.

Poultry.—It is by no means easy to assess the full importance of poultry and poultry farming in the British Isles. The returns made to the Ministry of Agriculture are only from agricultural holdings of one acre and over in extent, and there are many keepers of poultry who have far less ground than this. Furthermore many farmers do not accurately know how many poultry they have and in any case often tend to regard them as of minor importance. In 1950 official statistics recorded about 100,000,000 in the United Kingdom. Some 90 per cent. of the poultry are fowls. Although there are still large numbers of "barn-door" fowls picking up their own food around a mixed farm, the feature of the last fifty years has been the rise of great specialised poultry farms. Though widespread, the huge numbers in the home counties round London, in Lancashire and the West Riding reflect the influence of local markets. Lancashire is also amongst the leading counties in the matter of ducks, followed in turn by certain of the eastern counties. Geese, on the other hand, are kept to a much greater extent in Wales than in England. East Anglia is pre-eminent for the raising of turkeys, especially Suffolk and Norfolk. Poultry farming is at once an attractive, yet dangerous form of farming for the man with a little capital. It is just as dangerous to undertake poultry farming without knowledge and experience as it is to undertake any other form of farming. There is an increased efficiency in the egg-laying capacity of fowls, but except on speciality farms it seems that only about 100 eggs, or two eggs per week per fowl, has been reached throughout the country. This is a figure which could be greatly improved. There is still a large import of eggs and poultry.

There is an export, both of poultry and eggs, from Northern Ireland, whilst from the Irish Republic over a million live poultry are exported annually, and another 100,000 cwt. already killed. Many chickens are sent over alive, but most of the Christmas turkeys, being for quick sale at the cold time of the year, are killed first.

Number and Size of Agricultural Holdings

A very important survey of the farms of England and Wales was carried out in 1940 to 1943 and repeated ten years later. A somewhat similar survey, though on a sample basis, was carried out in Scotland. Previous to these surveys, all occupiers of agricultural land of more than an acre (in some cases more than a quarter of an acre) were classed as "farmers." On this basis there are over 300,000 "agricultural holdings" in England, about 55,000 in Wales and 75,000 in Scotland. A fifth of all the holdings in England,

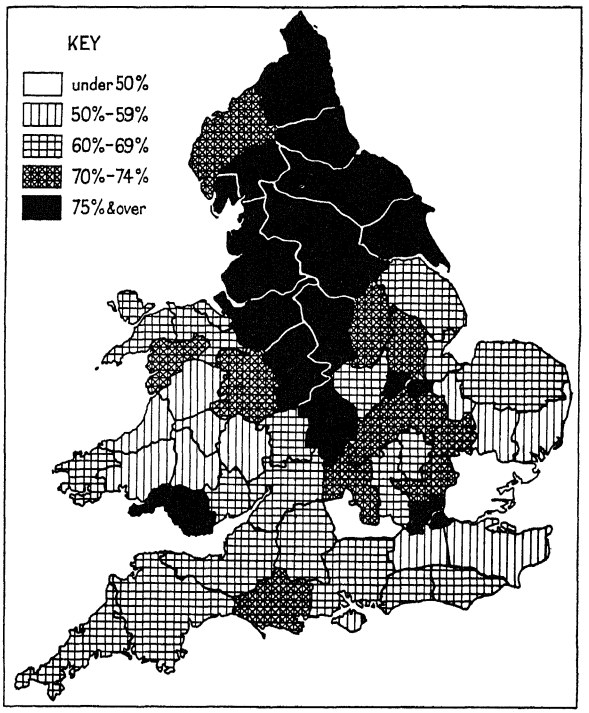

FIG. 112.—Proportion of Tenant Farmers in England and Wales
(From "National Farm Survey of England and Wales 1941–43," by permission of the Controller of H.M. Stationery Office)

however, are under five acres and cannot be called farms or their occupiers farmers.

The 1940 Farm Survey separated "full-time" farmers from part-time and spare-time, and "hobby" farmers. Apart from market gardeners and poultry farmers few full-time farmers occupy less than 25 acres. The Survey found there were 216,000 full-time farmers and that they farmed 88 per cent. of the improved land of England and Wales. If ten acres of rough grazing are reckoned as equivalent to one acre of improved grassland then the average

full-time farm is just under 100 acres. Speaking generally farms are smaller on good land, larger on poor land, though this is not true of marginal land where poor farmers are often found on poor land insufficient in quantity to maintain a good standard of life.

Roughly two-thirds of all farmers are tenants as against one-third owner-occupiers. Although the number of farmers and the size of holdings has remained remarkably steady since statistics were first collected over eighty years ago, the number of farm workers continues to drop. It was down to 700,400 in England and Wales in 1952.

Some Agricultural Industries

Sugar Beet.—The world's first beet-sugar factory was established in Silesia, Germany, in 1801. The new industry soon attracted the attention of Napoleon, who saw in fostering the home production of sugar a means of breaking the power of the British Empire, which had at that time almost a monopoly of sugar production. Napoleon may be regarded as responsible for the initiation of the subsidy system under which the industry grew in many European countries. Before the First World War, in the years 1909–1913, so important had European beet-sugar production become that it roughly equalled the total world production of cane. Germany, Austria-Hungary, Denmark, and Holland were large exporters and supplied Great Britain with nearly two-thirds of her sugar. In 1913, Germany alone supplied nearly half a million tons—more than all the cane sugar used in England, and equivalent to 47 per cent. of the total imports. One of the most remarkable features in the history of sugar is the fact that the British Isles remained for so long without a home-grown sugar industry. Efforts to establish factories in this country were made from 1909 onwards, plans for factories were arranged, and promises were extracted from farmers to grow the necessary beet. But the competition of bounty-fed cheap continental sugar in the open British market rendered all these schemes abortive. It is interesting to note, however, that the Cantley factory was built in 1912 before the First World War, very largely with Dutch capital, and thus the initiation of the modern industry in this country was mainly due to Dutch initiative. It was, of course, during the war that Britain felt the severe effects of not having a home-sugar industry. The beet-sugar producing countries of Europe were those that suffered most severely; although this was of advantage to the cane-producing countries overseas, the shipping necessary to bring supplies of sugar to England could ill be spared. The normal imports of sugar into the British Isles had approached 2,000,000 tons, and during the war supplies had to be carefully rationed. In March, 1917, the Treasury sanctioned an advance to the British Sugar Beet Society of £125,000 as a loan for the development of the Kelham estate in Nottinghamshire, but for various reasons the

factory was not ready to operate until March, 1921. In the meantime the Cantley factory, which had been disused during the war, was re-opened in 1920, and took beet which had been grown for the then uncompleted Kelham factory. At that time there was an import duty on sugars and great assistance was given to the home industry on March 30, 1922, by the remission of the excise duty; but it was recognised that high import duties could not be maintained indefinitely. The passing of the British Sugar Subsidy Act, in March, 1925, marked the beginning of a long and complicated story of direct state aid to the home sugar industry.

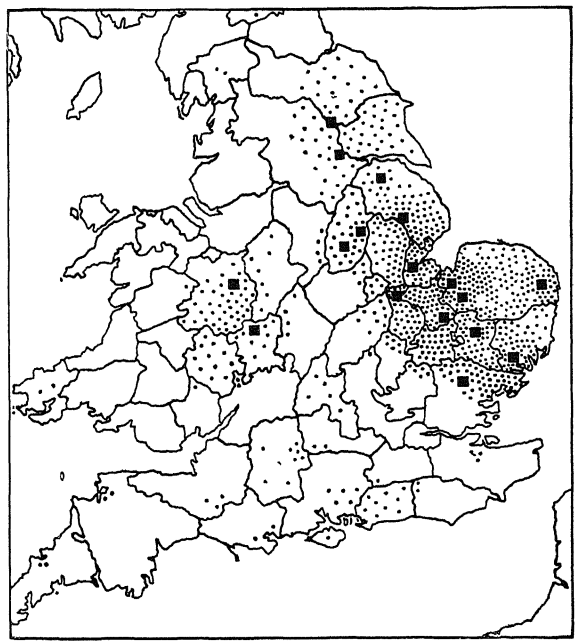

FIG. 113.—Sugar beet in England and Wales
Each dot represents 500 acres of sugar beet in 1951–1952. Each square represents a beet-sugar factory

By 1927–1928 seventeen factories in England had been established and by 1930–1931 the industry had taken on almost the pattern it has over twenty years later. Since 1942 the acreage under sugar beet has remained almost constant at 400,000 acres. There is one factory in Scotland—at Cupar in Fife; there are two in the West Midlands at Kidderminster and Alcott (Shropshire). The remaining fifteen are all in eastern England, stretching from Selby in Yorkshire to Felstead in Essex—actually at Bardney, Brigg, Bury St. Edmunds, Cantley, Colwick, Ely, Ipswich, Kelham, King's Lynn, Peterborough, Poppleton, Spalding, and Wissington.

It is interesting to analyse the position in 1931, to see what progress has been made from the cultivation point of view. The average yield in that year was 7·1 tons per acre, which was poor compared with the 8·8 in 1930, and the 8·7 in 1929. But the sugar content was higher—17·3 per cent.—as against 16·7 per cent. in 1930, but 17·7 per cent. in 1929, despite a poor season. On an average of the years 1939–1948 the yield had risen to 9·4 tons per acre with a high of 12·8 in 1950. The actual production of sugar average over a ton per acre and has therefore been maintained at 400–500,000 tons, more than a quarter of Britain's consumption.

The conditions necessary for the cultivation of sugar beet agree in general with those required for other root crops. It requires well-drained fertile loamy soil, whilst a certain proportion of lime in the soil is essential. It is an annual plant raised from seed and sown in the spring. The whitish parsnip-like roots are ready for digging towards the autumn. The roots are washed and topped, and are then ready for delivery to the factory. The first operation there is the slicing of the beet or the cutting of it into thin shreds. These are immersed in warm water so that a liquid containing the sugar is formed. This liquid is then treated with lime, which has, broadly speaking, the effect of removing impurities. The purified juice is then boiled in closed vessels in order to remove some of the water, which means it is converted into a syrup. The syrup is then heated in vacuum pans away from the air, and this has the effect of causing little crystals of sugar to start forming in the mass of the syrup. After a period of rapid boiling there are immense numbers of tiny crystals of sugar floating about in the syrup. The whole now forms a thick, sticky mass. This mixture is then put into pans with very fine wire mesh walls; the pans are then rotated very quickly indeed, perhaps at the rate of a thousand revolutions a minute, with the result that the liquid syrup flies away from the centre through the wire gauze and the sugar is left inside. This is in the condition of raw sugar, which has to be refined for the white sugar of commerce. The liquid or heavy syrup which is thrown off when the crystals are formed is called molasses. The residue of pulp from the beet applied either direct or as dung from the cattle fed on it makes excellent manure, and there is a steadily increasing demand in this country for wet pulp mixed with molasses, both a palatable and a valuable cattle food. The two difficulties in the establishment or prosecution of the beet-sugar industry remain to be mentioned. One is the need for close co-operation between the factories and the farmers; the supply of sugar beet must be assured from year to year. The second difficulty is that the sugar beet is a heavy, bulky commodity and transport costs are naturally serious. It is almost useless, therefore, for the farmer to grow sugar beet unless he has adequate transport facilities at low rates, and can thus

supply a factory not too far distant. At the same time beet must be grown in rotation with other crops, and the amount of land immediately surrounding any factory, however large, must therefore be strictly limited. These factors tend therefore to limit distinctly the size of the factories which are possible in this country.

REFERENCES

Report on the Sugar Beet Industry at Home and Abroad: Ministry of Agriculture and Fisheries Economic Series No. 27 (H.M.S.O., 1931). This report contains a full account of the industry from all points of view and is well illustrated.

Subsequent progress may be followed in the *Agricultural Statistics.*

The Canning Industry.—One of the spectacular developments in British industry in the years between the wars was the rise of the canning industry. There is no official return of output, but the following table gives an estimate of the output of canned fruit and vegetables in number of cans in the nineteen-thirties when the great rise occurred. It will be seen that in five years the output increased tenfold, from under 10 million cans in 1925 to over 100 million cans in 1932. Towards the close of 1932 there were nearly 60 factories (ten of which had come into production during that year) employing the modern mass-production automatic machinery.

THE EARLY RISE OF OUTPUT OF BRITISH CANNED FRUIT AND VEGETABLES (CANS)

1913	negligible	1929	16,340,000
1924	very small	1930	34,200,000
1925	very small	1931	83,000,000
1926	7,000,000	1932	100,000,000
1927	7,840,000	1934	120,000,000 from 76 factories
1928	7,930,000		

For some time there was a prejudice amongst the British public against tinned and canned goods generally, and there were even some packers who removed fruit and vegetables from cans received from abroad, repacking them in glass jars for the benefit of the fastidious British taste until the advent of war in 1939 swept away such prejudices. Large quantities of tinned fruit of tropical and sub-tropical origin not obtainable in this country are imported and used, for example, pineapples, peaches, apricots, etc. Despite the increase in output of British canned fruit and vegetables, there was no sign of diminution of imports of such exotic fruits until dollar and general foreign currency shortage intervened. The import of foreign tinned fruit for 1931, amounting to 150,000 tons, valued at £5½ million sterling, was easily a record up to that date. Pineapples represented 40,000 tons of this total and were the most important, but were followed closely by peaches and pears with 37,000 tons

each. Of the pineapple imports 90 per cent. came from Commonwealth sources, particularly from Malaya; but 90 per cent. of the peaches, pears, and apricots came from foreign countries, mainly the United States of America (California). Indeed, the United States alone sent 94,400 tons of fruit, or 25,000 tons more than in the previous year. This increase of 25,000 tons was equal to the whole of the output of canned fruit in Britain at that time.

In addition there was a large import of canned vegetables. For example, in 1931, between 3,000 and 4,000 tons of canned peas came from the Continent and the United States, nearly 1,000 tons of asparagus from the United States, and 5,000 tons of baked beans. Clearly the war and subsequent exchange position completely altered the position.

In the past one of the great difficulties of the British farmer growing fruit and vegetables for market has been the shortness of the English season. Thus too often a good season means a good season for everybody, a glut of fruit and vegetables and very low prices. Years ago, to give a personal example, the writer remembers being unable to get $\frac{3}{4}d.$ per lb. for first quality English plums picked and delivered to market, and alternately being unable to secure an offer at all for the fruit growing on the trees. Obviously, canning supplies a way of dealing with such a glut; provided that the area of production is near the cannery, the fruit can be picked when the weather is suitable and taken to the cannery and the operation of canning completed within 24 hours. A danger is that sufficient care will not be taken in the grading of the fruit. Maintenance of quality is essential for the prosperity of the industry. Similarly, it is undesirable for fruit to be brought from a distance and to suffer the disadvantages of carriage before being canned. A good start was made in the inter-war years by the introduction of a National Mark. The second great difficulty in the economic working of the canning industry is that the season of production is very short. Broadly speaking, fruit and vegetables are only available for canning in this climate for about four months—June, July, August, and September. To run a factory and to secure an adequate labour supply for four months out of the twelve is obviously a difficulty. From what has been said it is plain that the factory must be built near the areas of production, and thus the British canning factories of importance are those situated in the fertile lands of East Anglia, such as Fenland, and Norfolk and Suffolk. If a factory can be built at the same time near the seaboard, for example, at Ipswich, it may be possible to combine with the fruit and vegetable canning the canning of fish, so as to occupy the machinery for a greater part of the year.

The canning industry suffered a severe setback during the Second World War, partly because of the scarcity of tin plate. Taking

fruit alone, this is shown by the output of British canned fruits, expressed in thousands of tons.

1938	32·0	1946	21·7	1950	75·1
1939–1943 (av.)	4·0	1948	64·5	1951	74·3
1944	21·6	1949	89·1		

Recently, the process of quick-freezing or deep-freezing has opened up new possibilities of dealing with the fruit and vegetables which, in so many cases. Britain produces to perfection.

The Brewing Industry.—In view of the fact that a large proportion of the home-grown supplies of barley is destined for manufacture into beer, and in view of the fact also that the growing of hops is for the same purpose, brewing may well be classed as an agricultural industry. In the manufacture of beer the barley is first malted, then ground into coarse meal, and the first process in the actual making of the beer is the mixing of this meal, or malt, with warm water. The mixing is carried out very thoroughly in what are called mash-tuns, the malt and water being thoroughly mixed by mechanical stirrers. Much of the goodness of the malt passes into the liquid and the whole is called wort. This liquid is strained off from what is left, the remains of the barley are dried and sold to the farmers, forming a valuable cattle food. From about 11 cwt. of barley about 3 cwt. are thus returned to the farmer for use in feeding his cattle. In many ways this cattle cake is actually a better food than the original barley itself. The wort is then pumped into another part of the brewery and passes into the coppers. There two or three lb. of hops to a barrel of beer are added and the whole is boiled for about an hour and a half or two hours. The wort has now derived a bitterish flavour from the hops and has to be strained off from the remains of the hops. It passes into a "cooler" so that it comes out at about the ordinary temperature of a cool summer day, that is from 56° to 60° F. In large fermenting vessels into which the wort is now conducted yeast is added, and changes the sugar of the wort into alcohol. When the yeast has done its work it rises to the surface and the scum so formed is cleaned off. The beer is now ready for running into the great storage vats from which it can be run off into barrels as required.

The annual consumption of beer in the United Kingdom (1941–1950) is between 26 and 33 million barrels, a barrel containing 32 gallons or 256 pints. Very roughly this is about 130 pints per head of population per year. Consumption reached its highest level in 1945 (33 million barrels), but later dropped steadily. In the old days the brewing of beer used to be carried out very largely in small farmhouses, but it has become more and more concentrated in the large breweries. Even the smaller breweries are disappearing. One reason for this is the precision needed at each stage in the

complex operation. For example the quality of the water used in the malting process is very important. The best results are obtained from water which possesses a considerable permanent hardness due to the presence in solution of calcium sulphate. The well water from the Keuper Marls at Burton-on-Trent is of this character and is therefore particularly suitable. The brewing industry of that town is no doubt largely a result of this. Manchester, Warrington, Chester, and Liverpool are other brewing centres situated on the Trias, and on the Trias belt east of the Pennines there is Tadcaster. In some cases the salt is added artificially to the water—the process commonly known as "burtonising" the water. For years one of the largest breweries in the world was in Dublin, where Guinness's stout is made, though the stout is now made also in west London.

Vinegar is made from malt in very much the same way, but there is an additional process. The alcoholic liquid, not very dissimilar from beer, is run into pans which contain beechwood shavings that have been soaked in old vinegar. There are organisms in these which set up a change by which the alcohol is converted into the sour acetic acid of the vinegar. Hence the expression "pure malt vinegar."

Distilling.—Despite the decrease in consumption which is due to the high excise duties, changes in popular taste and demand of the export trade especially to America, whisky may still be regarded as the native drink of Scotland and Ireland, as beer is of England. In 1913–1914 nearly 27 million proof gallons were consumed in the British Isles (17·9 in England and Wales, 6·2 in Scotland, and 2·3 in Ireland), this representing 0·5 proof gallon per head of population. By 1926–1927 the total had fallen to less than 12 million gallons (8·4 in England and Wales, 3·1 in Scotland), representing only about 0·24 proof gallon per head of population. In the decade 1941–1950 total consumption of all spirits (i.e. whisky, gin, rum, brandy) in the United Kingdom had dropped to between 8 and 10 million gallons. In this period whisky for home consumption became a rarity. There are three stages in the manufacture of whisky: malting and mashing the barley, or the preparation of the wort, as in the manufacture of beer, the fermentation of the wort to produce the wash, and the separation of the spirit from the wash by means of distillation. For Scotch whisky barley is practically the only material used. In Irish whisky, barley, oats, wheat, and rye are generally mixed. The distillation is carried out in two main types of stills; there are the old-fashioned pot-stills, which consist of a vessel in which the wash is boiled and to which is attached a pipe to carry the vaporised ingredients of the wash to a condenser, where the distilled liquid falls into a receiver. The heat is supplied directly from a fire, but the distinctive flavour of pot-still whisky has been said with doubtful truth to be very largely due to the use of

peaty or other special fuels in the preparation of the malt itself. In the patent stills of the large distilleries those flavours tend to be absent from the whisky, which is more standardised. In Scotland, Banffshire is a focus of the industry.

THE NATION'S FOOD

The introduction of subsidies and the changing value of money render invalid comparisons between present and past expenditure on food, whether by the individual or the nation, but a comparison of quantities per head of population is both interesting and instructive.

TOTAL FOOD SUPPLIES PER HEAD OF POPULATION IN GREAT BRITAIN

	1907	1924-28	1950	1934-38	1950
Fresh milk (pints)	3·0	3·1	4 8	3·2	4·9
Dried and condensed	—	2·5	—	4·3	3·0
Cheese	2 7	2·9	2·5	2·7	3·1
Butcher's meat	31·4	30 9	13 8	28·1	23·2
Beef and veal	21 3	22 0			
Mutton and Lamb	18·7	8 1			
Other meat	1·2	1·1	11·5	3·2	4·4
Bacon	13 2[1]	14·4[1]	4·5	8·3	6 8
Fish	13·4	12·9	6·6	7·8	6·6
Total meat and fish	*59·2*	*59·3*	*36·4*	*47·4*	*41·0*
Eggs (number)	2·1[2]	2·2[2]	3·5	3·7	3·9
Butter	4·9	4·7	4·6	7·6	5·2
Margarine	1·5	3·8	3 9	2·7	5·1
Cooking fats			3·1	5·4	5·0
Total fats			*11·6*	*15·7*	*15·3*
Fresh fruit	22·8[3]	31·1[3]	19 2	34·5	
Potatoes	58·1	59·1	62·0	54 2	75·0
Fresh green vegetables	—	—	13·8		
Other vegetables	—	—	18·1		
Flour	64 0	63·9	51·7	59·9	62·8
Other cereals			16 7		
Sugar	24·6	26·5	16·4[4]	29·9	23·2

All figures in ounces per week, except where stated.

[1] All pig meat and lard.
[2] Shell eggs only.
[3] Fruit and nuts all kinds
[4] And preserves.

This table must be read with great caution as the figures, derived from different sources, are not directly comparable. The first two columns are calculated from *The Agricultural Output and the Food Supplies of Great Britain*, H.M.S.O., 1929. The third column, for 1950, is taken from *Domestic Food Consumption and Expenditure*, 1950, H.M.S.O., 1952, and refers to food consumption *in households only*, based on a sample survey of households. The last two columns are calculated from the tables of estimated food supplies per head of civilian population from the *Annual Abstract of Statistics*, 1938–1950, H.M.S.O., 1952. supplemented from *Post-War Contribution of British Agriculture*, H.M.S.O., 1947. It is the last two columns which should be compared with the first two, but allowances must be made for differences of classification.

Taking consumption per head, this table shows some interesting changes since the early part of the present century. There is comparatively little change—a slight drop—in the consumption of the staples bread and flour. On any reckoning there has been a very big decrease in the amount of meat eaten and this applies to both butcher's meat and bacon. It is better, because of changes in grouping, to take the total of all meats in making a comparison. Thus consumption was 45·8 ounces in 1907, 46·4 in 1924–1928, 39·6 in 1934–1938, and 34·4 in 1950.

Overall there has been little change in amount of sugar, but here, as in a number of other cases, the country was better off in the nineteen-thirties than either before or after. The drop in fish consumption is surprising. There has been a marked rise in milk, fruit and vegetables (including potatoes) and in butter and margarine, though exactly comparable figures are difficult to get.

Before one considers the sources from which Britain derives her food it is necessary to have at least a generalised mental picture of the changing pattern of world trade.

Prior to the First World War many of the "newer" countries were producing a surplus of foodstuffs (including animal feeding stuffs) and raw materials which they were anxious to exchange for British manufactured goods and were sometimes even willing to "dump" or sell to us at below cost. Britain had many investments overseas and payment of interest came largely in the form of foodstuffs, and so too did payment for services rendered, such as banking, insurance, shipping, and technical services. Tariff barriers were comparatively few and the flow of world trade was unhindered. British supplies of food could have come from many areas: they tended to come from those countries with which Britain had the closest ties.

The submarine menace of the First World War, shortage of shipping and the spectre of starvation turned attention—only temporarily—to increasing home supplies of food, but when the war was over, home production became an even smaller proportion of total consumption than before. There was, however, a deliberate attempt to stimulate trade within the British Commonwealth: Empire Free Trade became a slogan, the Empire Marketing Board was set up and various trade agreements involving Imperial preference were negotiated. The increase of food imports from Commonwealth countries was only a little greater than the increase from foreign countries.

The advent of the Second World War brought many changes. There was the tremendous drive to increase food production at home whilst the Ministry of Food undertook the overall planning of the nation's diet. The Government purchased in bulk both the home production and overseas supplies and then rationed the

total amongst the civilian and service populations. Private wholesale trading in food practically disappeared. When the war was over, relaxation of controls and return to private trading took place very slowly. The international situation so far as Britain was concerned was completely changed. There was no longer any automatic flow of food into the country as interest on overseas investments—the investments had for the most part been sold or otherwise "liquidated" to pay for the war. The world was divided into blocs—the Soviet bloc behind the Iron Curtain with very little foreign trade; the Dollar countries; the Sterling area (the British Commonwealth and certain other countries linked with the £ sterling). There was comparatively free trading between members of the sterling area, but shortage of dollars resulted in stringent restrictions on food imports from the United States and, despite membership of the Commonwealth, from Canada. Whereas, therefore, comparisons between the sources of supply of Britain's food before and after the First World War indicate changes in the world's supply position, comparisons of before and after the Second World War reflect the influence of man-made barriers.

Taking some of the more important items in order, the change in origin of our wheat and wheat-flour is particularly noteworthy. Before the First World War huge quantities came from the United States, but later Canada became easily the chief source, followed by the United States, the Argentine and Australia, these countries sending on an average over 90 per cent. of the total. The pre-1914 supplies from Russia have, of course, almost disappeared. Of other grains imported maize was very important in the inter-war years as food for live stock, and 35 million cwt. were imported annually, five-sevenths coming from the Argentine, one-seventh from British South Africa, and the remainder from Rumania and the United States. This import was cut by encouraging home production of animal feeding stuffs. We formerly imported annually about 30 million cwt. of meat, of which over 12 million was chilled beef from the Argentine. It is noteworthy that the import exceeded the home supply, only about 43 per cent. of the beef consumed being produced in the British Isles in the inter-war years. Five million cwt., mainly of mutton and lamb, came from New Zealand and Australia, whilst the five million cwt. of meat from Denmark was mainly bacon. Other supplies in smaller quantity came from the United States, Uruguay, the Netherlands, and Canada; whilst a feature of importance was the import of bacon from Poland. The increased home use of meat is at least one reason for the shortage of world supplies of meat. Over half the eggs used in this country are produced at home, but the import reached the stupendous figure of 3,000,000,000 in the inter-war years. When stated as 26,000 thousands of great hundreds it does not sound as much. Half

this huge quantity came from Denmark and Holland, rather less than a fifth from the Irish Republic and a tenth each from Poland and Belgium. Changes in world communications have been responsible for quantities of poultry coming from Australia and South Africa, whereas formerly the only country sending poultry to Britain was the Irish Republic. Turning to dairy produce there is practically no import of fresh milk, but considerable quantities of dried and condensed milk. The advantages of a fresh milk[1] supply are obvious, hence the desirability of concentrating on the production of this commodity in the country itself. Forty per cent. of the butter imports came in the inter-war years from the Empire, from New Zealand, Australia, and Ireland. Denmark sent us one-third of our total supply and the Argentine was another important source. New Zealand, easily first, and Canada sent us together 60 per cent. of our imports of cheese, the other countries being Holland and Italy. The details for vegetables and fresh fruit really deserve a chapter to themselves, because they illustrate in a remarkable way what can be done with improved methods of transport, specially constructed ships with special refrigerating machinery extending the markets for a commodity. Nevertheless in quality our vegetables can compete satisfactorily with anything imported which is grown under similar climatic conditions.

[1] "The one and only perfect and complete food known to man." See Professor H. E. Armstrong, *Nature*, April 29, 1933.

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The subjects considered in this chapter will be found studied at length in L. D. Stamp, *The Land of Britain: Its Use and Misuse*, London, Longmans, Second Edition, 1950.

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Agricultural Statistics:
United Kingdom: Part I 1946–1947 and 1948–1949. H.M.S.O., 1951, 1952.
Part II 1939–1940 to 1945–1946. H.M.S.O., 1949.
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Part I 1945–1949. H.M.S.O, 1952.
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Other important official publications include:
W. B. Mercer: *British Farming.* H.M.S.O., 1951—a popular, well illustrated and valuable summary.
National Farm Survey of England and Wales: A Summary Report. H.M.S.O., 1946.
How Britain was Fed in War-time, Food Control 1939–1945. H.M.S.O., 1946.
Post-war Contribution of British Agriculture. H.M.S.O., 1947 (Cmd. 7072).

The literature dealing with British agriculture is, of course, enormous. The following can only be regarded as suggestions to the layman who wishes to begin the study of the subject:
E. J. Russell: *The Farm and the Nation.* London, George Allen and Unwin,

1933. This book summarises in a small space the position in the nineteen-thirties of agriculture in all phases of the national life, and it is well documented with references to other sources.

For official details official publications should be consulted; some of the more important are:

The Agricultural Output of England and Wales in 1925. H.M.S.O.

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The Agricultural Output of Scotland in 1925. H.M.S.O.

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The Agricultural Output and the Food Supplies of Great Britain. H.M.S.O , 1929.

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Agricultural Statistics of Scotland. Department of Agriculture for Scotland (published annually up to 1938, Parts I and II).

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Atlases:

Agricultural Atlas of England and Wales 2nd Edition, revised by Malcolm Messer. Published by Ordnance Survey, Southampton, 1932.

H. J. Wood: *An Agricultural Atlas of Scotland.* London, George Gill & Sons, 1931.

L. D. Stamp: *An Agricultural Atlas of Ireland.* London, George Gill & Sons, 1931.

See also References following the next chapters.

CHAPTER XI

THE AGRICULTURAL REGIONS OF SCOTLAND

SOME years ago Scotland was divided into a number of simple agricultural regions by the late Dr. H. J. Wood.[1] Although the work of the Land Utilisation Survey and the County Reports enable the regions to be defined more exactly and although the production campaign of the years 1939 to 1945 wrought certain changes which

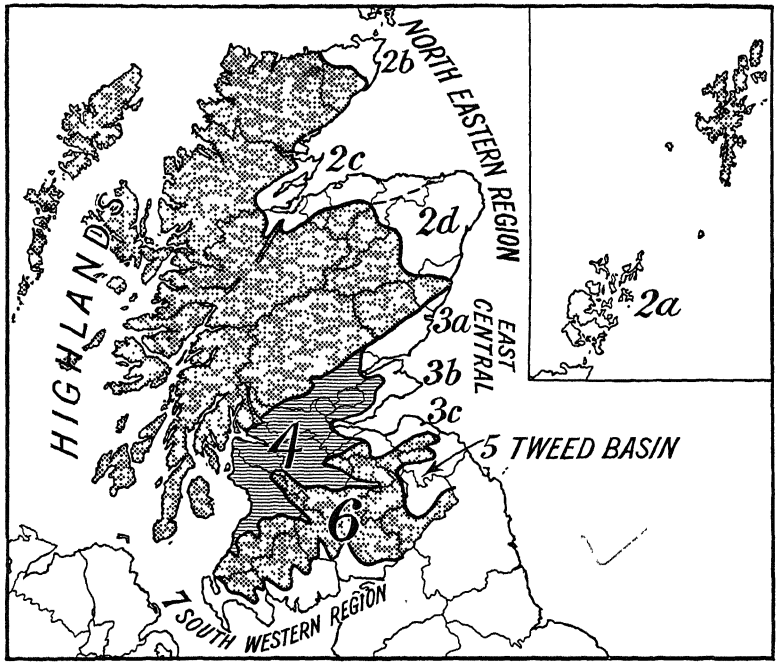


FIG. 114.—The Agricultural Regions of Scotland (after H. J. Wood). For explanation, see text

have persisted, the regions were based on environmental factors which remain. It does not therefore seem necessary to change the regional division which has been used in the earlier editions of this book, though the map, Fig. 114, should be compared carefully with the map of predominant types of farming prepared by the

[1] *An Agricultural Atlas of Scotland.* London, George Gill & Sons, 1931.

Department of Agriculture for Scotland[1] (Fig. 115), which is itself a post-war revision of the map previously prepared and which was based on statistics of 1938.[2]

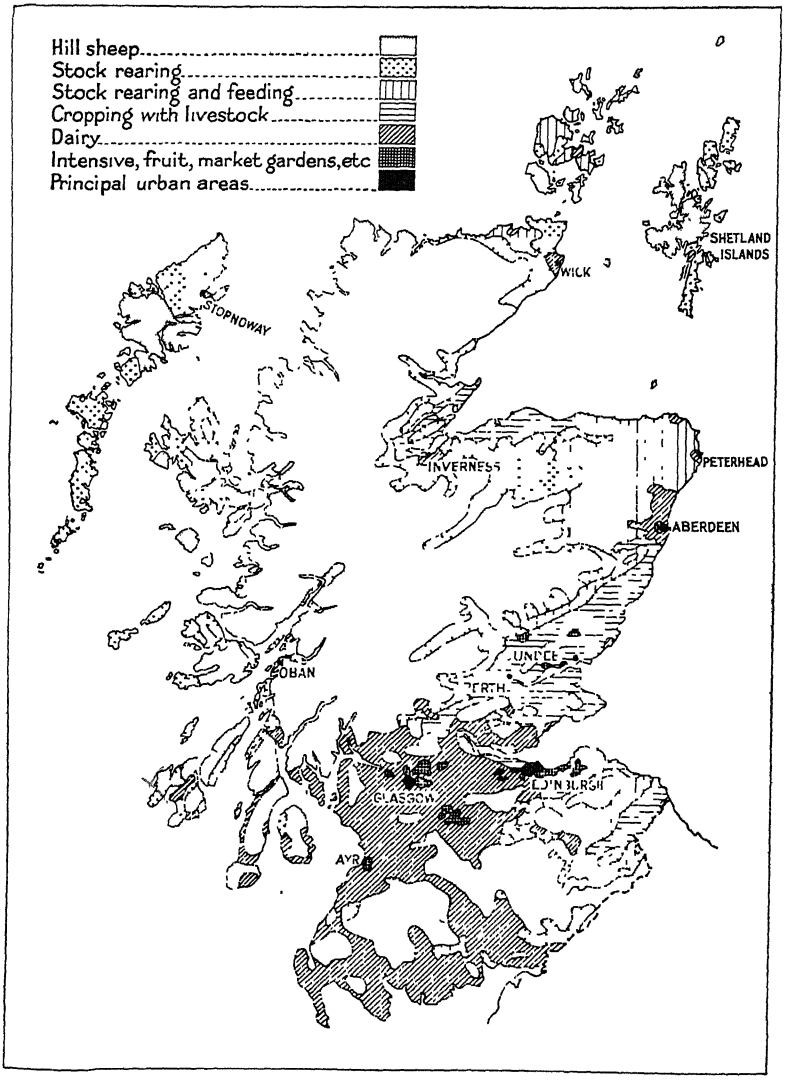


FIG. 115.—Predominant types of Farming in Scotland. This map refers only to full-time farms

(Modified from *Types of Farming in Scotland*, 1952, by permission of the Controller of H M. Stationery Office)

[1] *Types of Farming in Scotland.* Edinburgh, H.M.S.O., 1952.
[2] National Planning Series 1,625,000: Types of Farming, northern sheet.

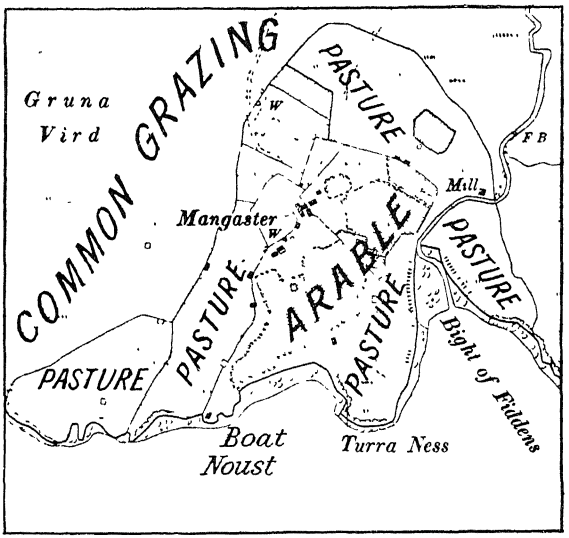


FIG. 116.—Map of a typical croft (Shetland Islands)

Notice the water supply (by wells) and the two approaches to the croft—one by land by rough tracks, the other by sea (the boathouse or Boat Noust has been marked). The corn grown on the patch of arable land was formerly ground by a water-mill (marked)—but most of these mills are now disused. Scale of map, 6 inches to the mile. (Based on the Ordnance Survey map, by permission)

FIG. 117.—Photograph of a crofting settlement in Shetland, taken in 1875

This large and flourishing settlement has now entirely disappeared—the site is occupied by moorland and is marked only by a few heaps of stones. This is typical of rural depopulation in many parts of the Highlands and islands of Scotland

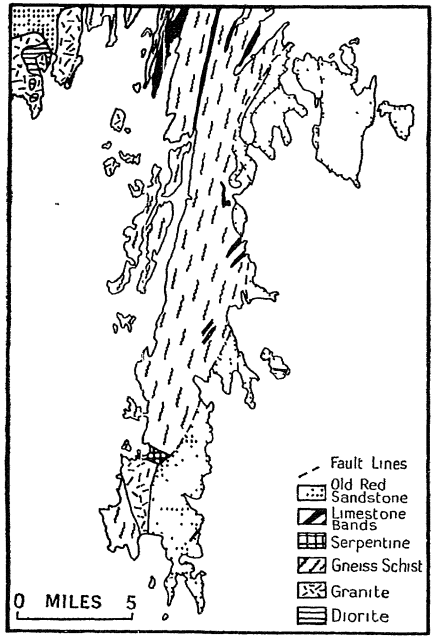


FIG. 118.—The geology of South Shetland

Fair Isle consists entirely of Old Red Sandstone Most of the settled land shown in Fig. 119 is on the Old Red Sandstone or on limestone bands

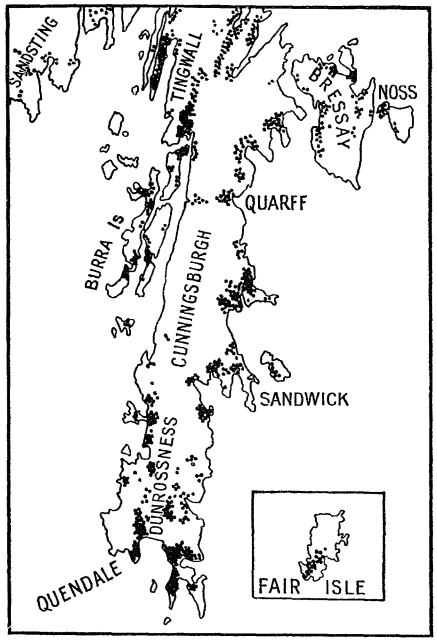


FIG 119.—Scandinavian settlements in South Shetland

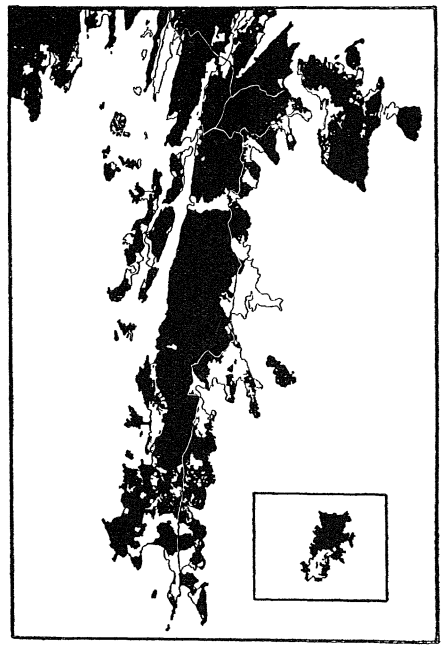


FIG. 120.—Present-day settlement in South Shetland. The black area is moorland: the blank areas settled or improved land

Diagrams to illustrate the influence of soil on settlement in the Shetland Islands—diagrams prepared by Professor A. C. O'Dell

Taking Scotland as a whole, it is remarkable that in the inter-war years 98·7 per cent. of the total area occupied by crops and grass was represented by permanent grass, rotation grass, oats, barley, wheat, turnips, and potatoes. The post-war position remains the same: the specialist crops, sometimes of great importance in England, play a smaller part in Scotland. The relative distribution of these crops thus gives a key to the farming economy of the various regions, including subregions.

1. The Highlands and the Western Isles

The Highlands of Scotland form a region well marked from both the physical and agricultural point of view and the most extensive in Scotland. The south-eastern boundary follows in general the line of the Highland boundary fault; only here and there are valleys which belong rather to the fringing corridor of lowland. To the east the boundary with the north-eastern agricultural region is not a sharp one, highland conditions disappear gradually as one passes eastwards. Although there are naturally variations within this huge area it is generally true to say that there are central cores of highland virtually uninhabited both by man and his domestic animals. These are the deer "forests"—though almost devoid of trees—which occupied 3,349,131 acres, nearly all in the Highlands, or 17 per cent. of all Scotland in 1938. In that year only 3 per cent. of the hill sheep were inside the forests, the bulk were found in the hill sheep farms which occupy much of the remainder of the Highlands. These farms generally have over 95 per cent. of their area in rough grazing, but most have a small acreage under such feed crops as rape. On the lower and rather better margins full sheep-farming gives place to cattle-rearing. In the west and in the islands, crofting prevails and all round the coasts fishing is combined with farming.

The hard old rocks, resistant to erosion, from which the great ice-sheets swept much of the previously accumulated soil have combined with climatic conditions to leave but few and small areas suitable for agricultural settlement. High rainfall, humid conditions, cool summers liable to be rainy and a lack of sunshine result in an abundance of surface water and wide areas of moor and bog. Drainage is difficult, and even when it has been carried out the wide spread of acid peat soils militates against cultivation. Limestone is but rarely available locally to ameliorate the acidity. Generally as one goes eastwards conditions become slightly more favourable with the lowering of the rainfall. Rural depopulation has long been the rule; men of Highland stock gravitate towards the more favoured agricultural lowlands, or to urban centres, and to foreign countries where better opportunities await them. The drier or wider glens, especially those of the Tay system towards

the east, and tracts along the western coastal fringe, are the most useful for settlement. Permanent grass and a few small crops of oats, turnips, potatoes, and barley are here to be found. The Highlands remain a problem area. Recent developments include the hydro-electric power and afforestation already discussed (pp. 101, 160), No longer do wealthy tenants exist willing to pay large sums for the rent of deer forests and hunting lodges and neither owners nor tenants can afford the upkeep of these large estates and the employment of ghillies and gamekeepers, though shooting, especially on the rather drier grouse moors, is still popular and important. Both hill sheep farms and cattle-rearing must be maintained to supply strong healthy stock to lowland farms, both for fattening and for breeding and the future may be in the improvement of the hill grazings by the use of Stapledon's methods and the development of large-scale ranching.

2. The North-Eastern Region

This is a coastal region of varying width and really may be described as falling into four parts:

(*a*) The Orkney Islands;

(*b*) The north-eastern part of Caithness, remarkable for its wide open stretches of arable land and absence of trees;

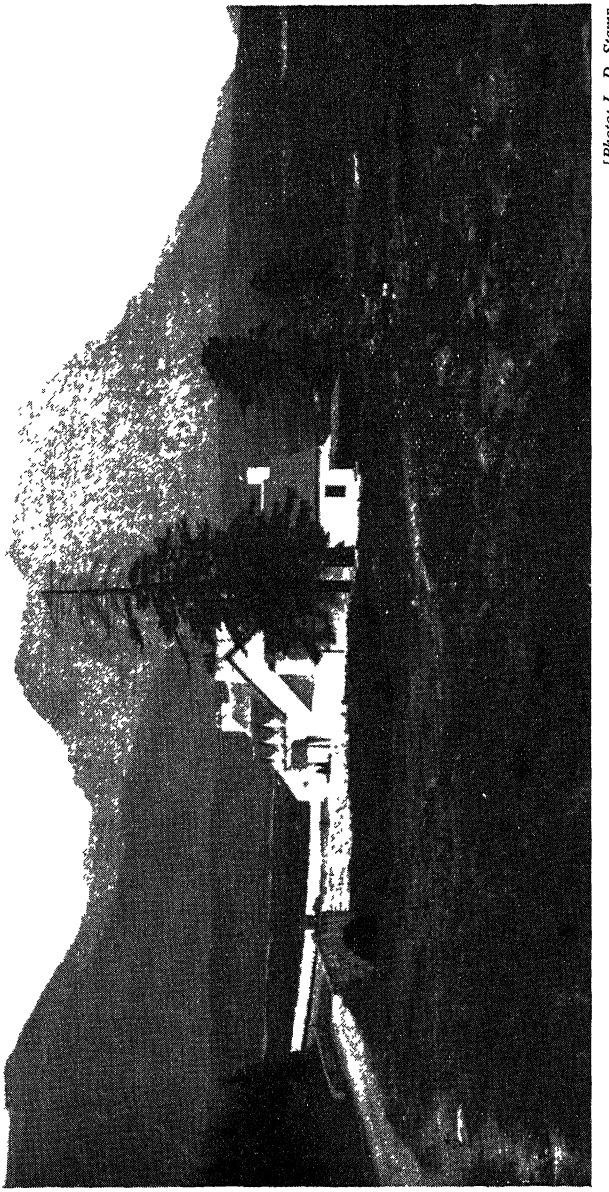
(*c*) The Moray Firth lands;

(*d*) The Buchan Plateau or the "shoulder" of Aberdeenshire and Banffshire.

In the three northern tracts the area is, in the main, underlain by Old Red Sandstone, and in Aberdeenshire by granitic and metamorphic rocks. There is in general a covering of drift, and the moderately acid soils are suited to the dominant crops—rotation grass, oats, and turnips. The summers are too cool for the ripening of wheat; but in the favoured areas, particularly around Moray Firth and along the coastal strip from Moray Firth to the shoulder of Aberdeenshire, barley is of considerable importance, not, however, in the Orkney Islands or Caithness. It is remarkable that there is little permanent grass. There is extensive pasturage of sheep and cattle on the fringes of the moors, but where the land is improved it is ploughed and on the ploughed land a six-year rotation is a common rule—oats, turnips, oats, grass, grass, grass. The economic development of the region owes much to the introduction of turnips, valuable both as a feeding and as a cleaning crop.

As shown on Fig. 115 each of the main towns (Thurso, Wick, Inverness, Peterhead, Aberdeen) has given rise to a small dairying area to supply local needs. The larger coastal towns with their interest in fishing are rather apart from the main agricultural belt as a whole. Over most of the remainder stock rearing and feeding

predominate—especially of beef animals of the Aberdeen-Angus breed. On the richer Moray Firth lowlands the feeding is based on



[*Photo: L. D. Stamp*

FIG. 121.—Kingshouse, near the head of Glencoe

Typical of the old hostelries found frequently in the loneliest and wildest parts of the Highlands and suggesting the greatest industry of the region—sport—for these hotels are used mainly by sportsmen

arable cropping. The areas as a whole are too remote for dairying. The Buchan Plateau with much of inland Banff and Aberdeen are very extensively forested.

3. The East-Central Region

This is the smaller, drier part of the Central Lowlands of Scotland. It is favoured by varied and often fertile soils, many of them of glacial origin, and by good climatic conditions, with drier sunnier summers than are usual farther north, and an annual rainfall which is generally less than 30 inches and sometimes less than 25 inches. Arable farming is the rule and commonly a six-year rotation is practised of oats, potatoes, wheat, turnips, barley, grass. Thus in many parishes there is a remarkably equal acreage under these six leading crops, whilst permanent grass occupies an acreage which is usually less than that of rotation grass. The produce of the arable land is, however, devoted to feeding of livestock and is not for sale off the farm. The region is divided into three parts by the Firths of Tay and Forth:

(*a*) The Angus region lies mainly in the county of that name and southern Kincardine and eastern Perth. It includes part of Strathmore and the coastal belt (with the Carse of Gowrie), with localised special development of, for example, small fruit.

(*b*) The fringe of the county of Fife. Here sugar beet is now of considerable significance.

(*c*) The northern strip of West Lothian and Midlothian and the greater part of East Lothian, limited roughly to the south by the 500 foot contour, and long famed as one of the most favoured agricultural regions of Scotland. Edinburgh and the other towns of the area have exercised their influence and have resulted in increased importance of market gardening, dairy farming, and pig rearing.

4. The West-Central Region

This occupies the larger part of the Midland Valley of Scotland with a rainfall in the west which may exceed 60 inches per annum. The line of volcanic hills with their rough sheep pastures may be regarded, from the agricultural point of view, as outliers of the Highlands. The summers are cooler and wetter and have less sunshine than the eastern region, and thus the proportion of permanent and rotation grass is high. Cereals other than oats are almost absent; turnips play a smaller part in farm economy here than they do in the east of Scotland, whilst potato production on a large scale is limited to certain localities. This is pre-eminently a dairying area, the home of the famous Ayrshire cattle. The raised beaches along the coast of Ayrshire with their sandy soils and mild spring weather have given rise to quite a specialised early potato industry centred on the town of Girvan. The demand from the towns obviously exercises an influence here as it does noticeably on the main centres of the dairying industry. As Dr. Wood

says of the western area, "it is a tributary of Glasgow, the economic tentacles of which grip the whole of the west-central area with varying strength relative to distance from the capital of the west." The old-established orchard area of Lanark is noteworthy—it lies in the Tweed valley protected from the winds which sweep over the uplands.

5. The Tweed Basin

The agricultural region of the Tweed Basin is limited by a semicircle of moorland, and indeed the edge of the moor may be said to form the limit of the region. Throughout the whole permanent and rotation grass are of almost equal importance. Oats are, of course, the leading cereal crop, but turnips, winter food for sheep, are everywhere important, as one would expect in a region where upland and lowland are integrally linked in a pastoral farming régime. Potatoes are unimportant. Towards the mouth of the Tweed there is a sub-region, the Merse of Berwick, which is distinctive in that it has a considerable acreage under wheat and still more under barley. It will be found that this area extends into the northern part of Northumberland. The Tweed Basin includes much of the "Scott country" and is remarkable in many ways for the English appearance of its scenery, with its hedges and numerous scattered trees giving a well-wooded appearance. Cattle are numerous in the lower-lying districts of mixed farming, but the district is unique in the whole of Scotland, and indeed in the British Isles, for the number of sheep it carries. In the upper basin, in Tweeddale, Ettrickdale, Teviotdale, and Lauderdale, the density of the sheep population is phenomenal, and large sheep farms are characteristic. The poorer sheep pastures support the black-faced sheep, the better pastures at lower levels the Cheviots, whilst an improvement of breeds on lowland farms has been carried out by crossing with Southdown and Leicester. There is, of course, a winter movement from the higher land to the lowlands. For an account of the woollen industry, see Chapter XIX.

6. The Southern Upland Region

The greater part of this region is occupied by moorland, but the Southern Uplands differ from the Highlands in the gentler relief of the hills and in the better pasture which they afford, and hence the greater density of the sheep population. The Southern Upland region is essentially the domain of the black-faced sheep. Settlements are mainly located in the valleys, and on the river terraces of these valleys there are fields, usually of permanent grass, sometimes of sown grass, and still less frequently of oats and turnips. Most of the larger valleys, of course, afford important routeways and the

improved access which results has led to the extension of dairying from the lowlands on either side.

7. The South-Western Region

This lowland region borders the Southern Uplands from the head of Solway Firth on the east to Wigtownshire on the west. On the east are the important dales breaking into the Southern Uplands, in the centre is the coastal tract or the Rhinns of Galloway. The region has a relatively heavy rainfall of up to 50 inches and cloudiness is a characteristic feature. Wheat and barley are little grown under such climatic conditions; oats form the principal crop, but the greater part of the land is under permanent grass or sown grass. It is only towards the drier east, for example in Annandale, that one gets a considerable proportion of turnips. The whole region has large numbers of cattle, especially dairy cattle, and usually Ayrshires. The native black Galloway cattle are also characteristic. The mild climate permits the cattle to be kept in the open all the year round. Quantities of milk are sent to the towns south of the border and the manufacture of butter and cheese is far less important than formerly. There is a tendency, but not so marked as in Ayrshire, to lay down under grass for as much as eight or ten or even more years land which has been ploughed, and then to plough it for two or three years before laying down again to grass. It is always difficult to decide whether this is strictly rotation grass or permanent grass.

The upper limit of cultivation in Scotland varies greatly from one part of the country to another, and the factors which determine it are worthy of more attention than they have received. A humid atmosphere and soggy ground seem responsible for a very low limit in Wigtownshire (usually observed at a little over 200 feet), increasing in the dales and the drier east.

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CHAPTER XII

THE AGRICULTURAL REGIONS OF ENGLAND AND WALES

It would be hard to find an area anywhere in the world of comparable size where wide variation in types of soil consequent upon complicated geological structure, considerable variation in relief, and by no means unimportant differences in climate between west and east, south and north, combine to give such a wide variation in agricultural conditions as in Britain. It may even be foolish to talk of the economic condition of British farming or of the British farmer, or to put forward sweeping proposals for the amelioration of present conditions without due regard to local, one might even say parochial, conditions. Because of the immense importance of this aspect of British agriculture, an attempt is made in this chapter to divide England and Wales into broad agricultural regions, and in some cases to suggest a tentative division into sub-regions. It will be noticed at once that these agricultural regions show little or no relationship to administrative divisions. Thus statistics arranged on a county basis can be very misleading in forming comparisons. Even the statistics collected by the Ministry of Agriculture and Fisheries on a parish basis and not published are frequently insufficient in detail. It is a well-known fact that a large proportion of English parishes owe their peculiar form (witness the long narrow parishes stretching from the chalk downs of the north of Surrey to the heart of the Weald) to the necessity[1] of sharing fairly between neighbouring parishes good land and poor, upland pasture and lowland pasture, suitable for sheep and cattle respectively, light friable loamy land for tillage and heavy clay land unsuitable for crops. It was one of the main objectives of the Land Utilisation Survey of Britain, by recording the use made at the time of every field in Britain, to provide for the first time an exact record of the distribution of different types of utilisation. In the County Reports an attempt has been made to evaluate the relative importance of the various factors, such as soil, elevation, aspect, drainage, accessibility, and certain economic factors in determining the type of farming in each area. Although the war-time food-production campaign of 1939–1945 altered the proportion of arable and grass and pushed back the moorland fringe in places, the broad pattern of agricultural regions remains.

[1] But see the comments in Chapter XXV.

The broad division into a Highland Zone in the north and west and a Lowland Zone in the south and east, which has already been repeatedly used, affords also a broad general distinction of Britain into two agricultural zones. The older rocks to the north and

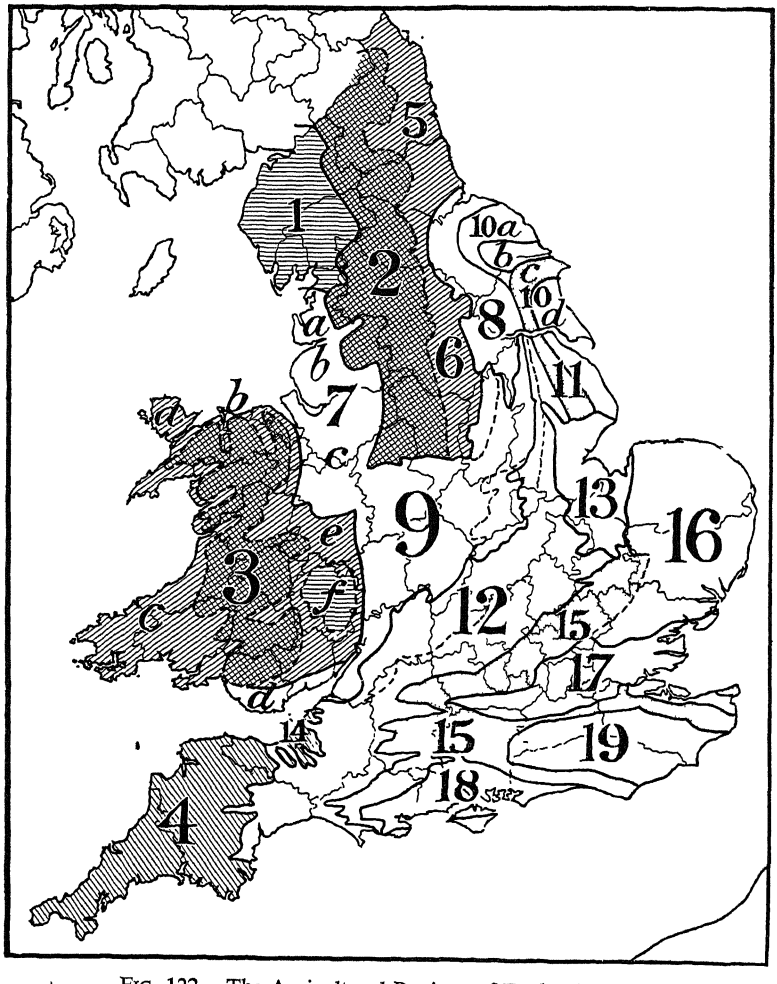


FIG. 122.—The Agricultural Regions of England and Wales
The regions are numbered to correspond with the descriptions given in the text

west with their comparatively poor siliceous soils are on the whole upland regions enjoying a heavy rainfall—in almost all areas over 30 inches. Soil and climate combine to render arable farming of secondary importance in nearly all areas. Where arable farming is carried on the crops which can be grown, as already noted, are

limited and serve mainly to provide winter feed for the animals. The lands to the south and east, on the other hand, with their younger and less resistant rocks have soils on the whole more suitable for agriculture. Over the Midlands and east the rainfall tends to be almost everywhere less than 30 inches, and though in southern

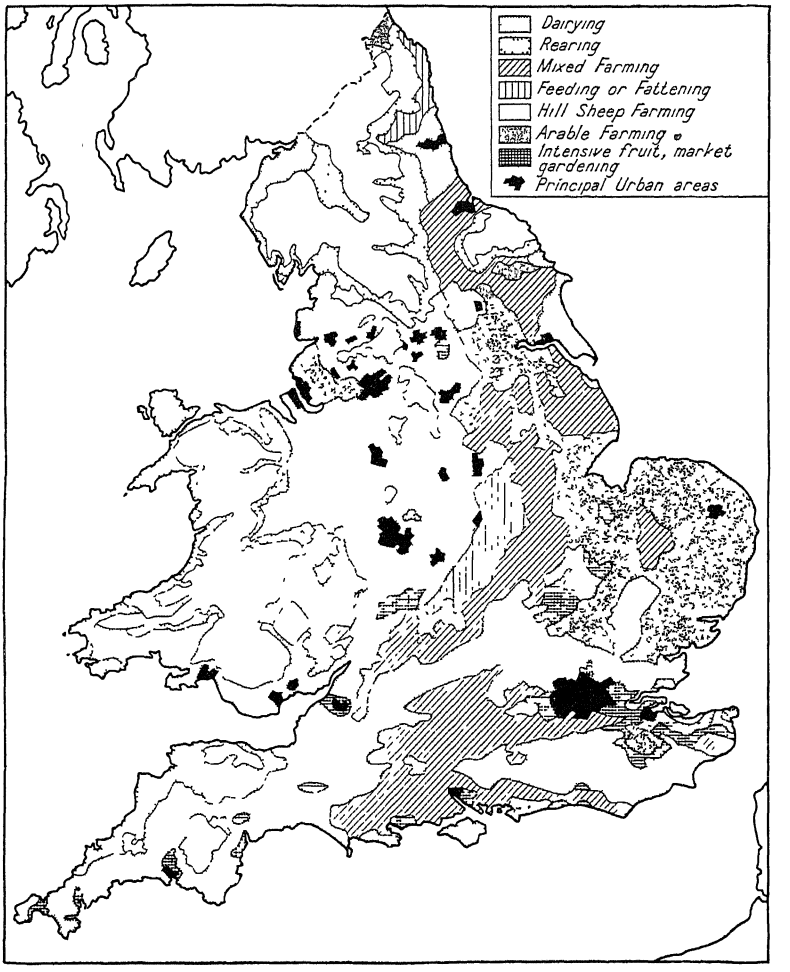


FIG. 123.—Predominant Types of Farming in England and Wales

England south of a line joining the Thames and Severn most of the higher ridges have a rainfall of over that figure, nowhere does one find the heavy annual falls characteristic of so much of the north and west. Even so there is a broad general distinction between the

damper lowland cattle-farming tracts and the drier eastern predominantly crop-farming tracts.

In general, the cultivable and habitable tracts of the Highland Zone form tongues of varying size projecting into the great expanse of moorland and hill pastures: in the Lowland Zone it is the less fertile uplands which form islands in a sea of cultivable and habitable land.

A. REGIONS OF THE HIGHLAND ZONE

1. The Lake District or Cumbria

This region, consisting as it does of a central knot of mountainous country with a very heavy rainfall and a surrounding ring of lowlands (broken only in the south-east), exhibits considerable differences from the agricultural point of view; but because of the movement of animals (particularly sheep) from one part to another, according to season, there is a certain essential unity in the whole tract. Broadly it consists of four parts:

(*a*) *The Central Mass*, with rough hill pastures supporting fell sheep in the summer only and cattle on the damper pastures of the broader valleys. Here is seen to perfection the northern shepherd with his wonderful care of the sheep and his amazingly clever sheep-dogs.

(*b*) *The Eden Valley* on the lee side of the mountains, with a comparatively fertile red soil and a rainfall falling in places to as low as 30 inches. Thus there is a considerable proportion of arable land, but owing to the northern situation no wheat and no barley are grown, the leading crops being rotation grasses, turnips, and swedes—obviously grown for the feeding of the large number of cattle (beef cattle more important than dairy cattle).

(*c*) *The Solway Plain*, where conditions are similar, large numbers of the fell sheep being driven to the pastures for feeding in the winter months when the fell pastures are snow covered.

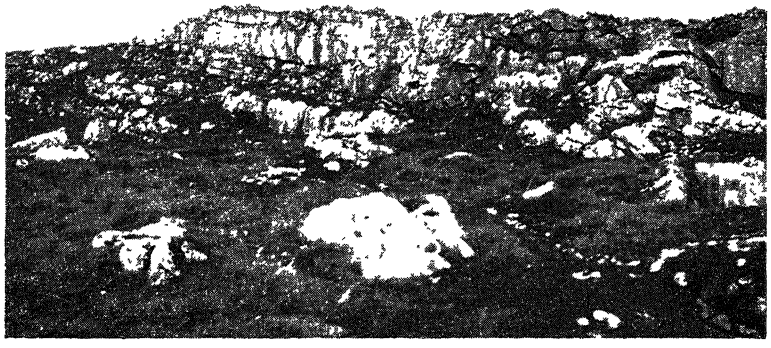
(*d*) *The south-western and southern fringe*, undulating land more exposed to rain-bearing winds, and hence with a heavier rainfall and much less arable farming. There is much woodland and much permanent grass, and cattle rearing takes the leading place.

2. The Pennines

The eastern slopes of the Pennines are reserved for special consideration. The main mass of the Pennine uplands is of course occupied by moorland or rough-hill pasture. Considerable tracts, especially of the Millstone Grit areas of the Pennines, are "reserved" as gathering grounds for water supplies of the large towns on the flanks of the Uplands (see Fig. 74), and here both animals and human inhabitants are few. Elsewhere sheep are almost the only tenants, though on the lower slopes they tend to share the

pastures with limited numbers of beef cattle. As in all the less accessible pastures of the Highland Zone—cf. Wales—there is often extensive cattle breeding, the animals being sold to lowland farmers for fattening.

South of the tabular mass of sandstone which forms the High Peak, the Pennines take on a different aspect. Geologically this is the country of the Derbyshire Dome, with extensive areas of Carboniferous limestone; much is scenically very attractive whilst agriculturally dairy farming has spread both into the valleys and over some of the hill lands.



[Photo: L. D Stamp

FIG. 124.—Limestone pastures

On the southern Pennines, at 1,100 feet, near Buxton. Notice the three black sheep

3. Wales and the Welsh Borderland

Agriculturally the Welsh massif consists of a great core of moorland or rough hill pasture and a surrounding fringe of land of greater agricultural utility. The central core of rough hill pastures occupies an irregular area, but covers in all at least 2 million acres compared with a total for Wales of 5 million acres. Almost the only tenants of these hill pastures are the Welsh mountain sheep, and they can only be pastured there for comparatively short periods in the spring and early summer. The surrounding fringe may be divided as follows:

(*a*) *Anglesey.*—This island, with its low surface and its rainfall averaging just below or just above 40 inches, has remarkably little rough pasture, but a very high proportion of permanent grass.

The land which is under the plough is very largely devoted to grass or to oats, all other crops being relatively unimportant. Until 1939 cattle farming for beef production rather than for milk was the leading occupation, though sheep were also numerous. Lately dairying has made great strides.

(*b*) *The valleys of North Wales, and the Lleyn.*—With a heavy rainfall and, in addition, almost constant humidity, grass, as one might expect, is much more important than ordinary crops. On the arable land the leading cereal is oats, and as everywhere in the west wheat and barley are unimportant. Several subsidiary crops such as peas and beans common in eastern England are almost

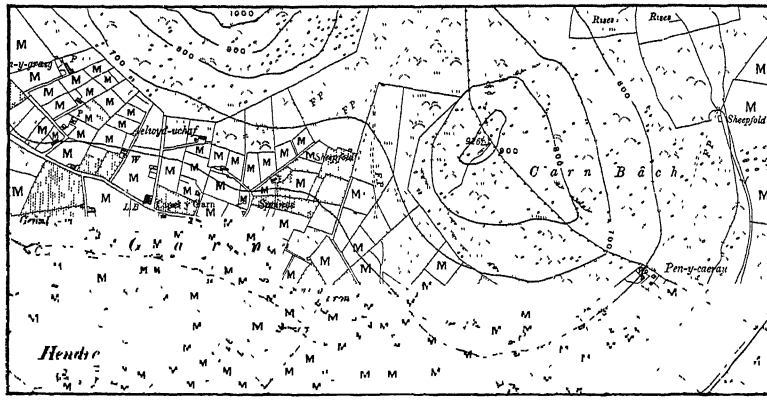


FIG. 125.—A section of marginal hill land in North Wales

Typical of farming areas in the highland masses of the western part of Britain—innumerable tiny fields of which about 15 to 20 per cent. are ploughed (shown by dotted areas), the remainder under grass (M), but which may be ploughed at intervals. All have been wrested with difficulty from the main mass of moorland, which will be seen to have re-invaded many of the enclosed areas. This is a section of one of the original field sheets of the Land Utilisation Survey (1932). The result of the war was to show much reclamation in land of this sort. Scale, 4 inches to 1 mile. (By permission of the Ordnance Survey and of the Land Utilisation Survey of Britain)

unknown; whilst root crops—turnips, swedes, and mangolds—are quite unimportant. These lands, of course, are cattle and sheep lands. Again, there is the quite important movement of sheep between the hill pastures in summer and the lowland pastures in winter.

(*c*) *South-western Wales.*—The western two-thirds of Cardiganshire, the whole of Pembrokeshire, the whole of Carmarthenshire, and the small western portion of Glamorgan lie in general to the west of the great belt of upland pastures. Until 1939 these counties were for the most part under permanent grass and there was comparatively little land under the plough. When one compares conditions with those in Ireland the small importance of potatoes is remarkable; this is true of all root crops. This is pre-eminently a cattle country with a large proportion of dairy cows. Pigs again

appear in numbers, but sheep are now relatively unimportant. Farms accessible by good roads were quick to turn to dairy farming; those not accessible to the daily milk lorry are compelled to carry on mixed farming. During the war with the policy of each farm producing its own requirements of feeding stuffs there was a great increase in ploughland.

(*d*) *The Vale of Glamorgan and Plain of Gwent.*—To the south of the moorlands of the South Wales coalfield there is a tract of country which, although it lies within the boundaries of Wales, is really a detached portion of the Midlands and scarplands of England. This Vale of Glamorgan is an area of mixed farming. To the east of the coalfield is the red land of Gwent in Monmouthshire.

(*e*) *The Welsh Borderland.*—To the east of the main central mass of the Welsh mountain moorland or hill pastures there is a belt of country stretching eastwards as far as the limit of the Welsh massif (which may be described as running north and south along the Malvern Hills). It is a varied area with broad valleys penetrating amongst the mountains and including, for example, the Vale of Powis, in which Welshpool and Montgomery are situated, but comprising also rolling uplands such as those which occupy the southern half of the county of Shropshire, Radnor Forest, and Clun Forest, as well as the rolling country which merges into the Plain of Gwent in the county of Monmouth. Two areas may be separated from this general mass. One is the Forest of Dean (still largely forested) and the other is the Plain of Hereford. For the remainder it is, for the most part, cattle country with rearing on the hills, dairying in the plains. On many of the drier pastures sheep are numerous.

(*f*) *The Plain of Hereford.*—This is a remarkable and varied basin with rich red soils derived from the marls and cornstones of the Old Red Sandstone and the overlying drifts. It lies in the lee of the Welsh hills and over the greater part the rainfall is under 30 inches a year. There is little mountain pasture, and although permanent grass is an important feature the distinctive character of this tract, compared with the rest of the Welsh massif, is the considerable acreage under the plough. Oats and appreciable quantities of wheat and barley are grown as well as root crops—including some sugar beet. This is the area which in the eastern part, like the neighbouring parts of Worcestershire, is famous for its hop gardens, the only other centre of importance apart from the Weald. Fruit orchards, particularly of apples, occupy a large area, so that Herefordshire becomes one of the important cider-producing counties. Cattle are, of course, numerous, but sheep not nearly so important as in most parts of the Welsh massif. The Plain of Hereford is a "basin" amongst the hills and may sometimes form in winter a "frost pocket" where cold, heavy and stagnant

air tends to remain: in summer fair warm conditions may prevail for longer periods than elsewhere.

4. The South-Western Peninsula

Although this is another area where the old rocks tend to yield an indifferent soil, two features distinguish it agriculturally from other regions in the west of England. One is the plateau character of much of the surface which renders areas easily ploughed though sometimes ill-drained, the other is the remarkable mildness of the winter which encourages certain crops to mature early. The higher lands of Exmoor and its outlier, the Quantock Hills of Somerset, in the north, and the granite masses of the south, particularly Dartmoor and Bodmin Moor, as well as Land's End and the Lizard area, are given over to rough hill pasture supporting but a few sheep. Of the remainder of the area, whilst permanent grass came to exceed tilled land in acreage in the thirties, Cornwall especially was rather remarkable for the large amount of land remaining under the plough. The plough-up campaign of 1939–1941 produced a great change in Cornwall, to a less extent in Devon, and the practice of taking the plough round the farm produced almost 100 per cent. ploughland in some areas. Certain of the drier tracts with more favourable soil conditions favour limited quantities of both wheat and barley, though of course being in the west of England oats remain the dominant grain crop. But the largest areas of ploughed land are occupied by fodder crops which tend to emphasise the great importance of the cattle-rearing industry, particularly the dairy-farming industry, providing the famous Cornish butter and Devonshire cream. The old emphasis was on butter, cheese, and cream rather than on milk, since the south-western peninsula long remained too inaccessible from the great centres of milk consumption for fresh milk to be a first consideration. But for direct supply of milk to factories the position is different, so that Nestlé's and other firms established collecting stations. The western half of Cornwall in particular is remarkable for the very high density of the pig and poultry population, whilst the climatic conditions of the sheltered valleys especially around Penzance and north of Plymouth is reflected in the large production and export to other parts of the country of early flowers and vegetables, for example, broccoli.

B. TRANSITIONAL REGIONS

5. Northumbria

This region, which may be alternatively described as north-eastern England, occupies the eastern halves of the counties of Northumberland and Durham and a portion of the North Riding of Yorkshire. Broadly, there are two parts: (*a*) the gentle eastern slope of the

Pennines and the undulating country between the Pennines and the sea in Northumberland and the northern part of county Durham, and (*b*) the lower Tees basin. The first is a region of indifferent soils, and the proportion of arable land to permanent grass steadily increases as one gets on to lower ground towards the coast. Durham is world famous for its Shorthorn cattle or "Durhams," but the crops which can be grown are those which are not of exacting requirements. There is very little wheat, for example, and root crops are comparatively unimportant. Near the actual Scottish border, however, the rather richer land there supports a considerable growth of barley and of turnips and swedes. Over the remainder oats and fodder crops are the most important, and reflect the importance of cattle-rearing and sheep-breeding industries. On the lighter drift soils of the lower Tees basin and in the Magnesian Limestone belt of eastern Durham conditions are much more favourable for arable farming. Moderate crops of wheat and barley, and considerable crops of oats, potatoes, turnips, and swedes are grown, and there are large tracts under fodder grasses. Cattle and poultry are important amongst animals; and it is in some respects a function of this region to supply agricultural commodities to the poorer lands farther north on the coalfield. The lower Tees basin is linked through the Northallerton gap with the agriculturally comparable Vale of York (see Fig. 122).

6. The Eastern Slopes of the Pennines in Yorkshire and Derbyshire and the Nottinghamshire Border

This region is terminated eastwards by the fertile Vale of York, and in it agricultural conditions resemble in general those of the region farther north in Northumbria. Spurs of moorland separate the fertile, attractive and famous Yorkshire dales of the Swale, Ure, Nidd, and Wharfe, farther south in the drainage basins of the Aire and Don, agricultural utilisation is overshadowed by industrial.

In the old western parts of the coalfield there are many small holdings to which miners and industrial workers retire, keeping a few poultry and pigs on poor land where large-scale farming would be difficult. The unique rhubarb-growing area south-west of Leeds is on heavily manured Coal Measure soils which are otherwise very sour.

C. REGIONS OF THE LOWLAND ZONE

7. The Plain of Lancastria

Geographically and agriculturally the Plain of Lancastria comprises the western half of the county of Lancashire, that is west of the moorland country, practically the whole of the county of

Cheshire, the detached portion of Flintshire, and the northern half of the county of Shropshire, including the area round Shrewsbury. The industrial development of South Lancashire has tended to obscure the very great importance of that county from the agricultural standpoint. Practically the whole area is a lowland with a rainfall varying between 25 and 30 inches. Almost the whole is underlain by the red rocks of the Triassic period. The soils derived from the Upper Series—the Keuper Marls—are comparatively heavy, and thus differ from those derived from the Lower Series, the Bunter Sands, which are comparatively light. The greater part of the plain has, however, been covered with glacial drift, and it is the character of the glacial drift which really determines local agriculture. In some areas, especially near the hills, heavy Boulder Clay is found, unsuitable for cultivation and hence devoted in the main to permanent pasture. Where the soils are lighter and more loamy arable farming becomes important, and there are large stretches to be described as amazingly fertile. Three main areas may be distinguished in the Plain of Lancastria:

(*a*) Lancashire north of the Ribble basin, including the Fylde district, but excluding Bowland Forest, which is an extension of the Pennines. Heavy soils mainly under permanent grass and with comparatively little arable land here prevail. This is an important dairying region with a very large number of dairy cattle, pigs, and a truly remarkable number of poultry. Naturally a large proportion of the products is destined for the industrial towns of the southern half of Lancashire. In addition large numbers of sheep from the neighbouring moorlands are pastured, especially in winter.

(*b*) South-western Lancashire and the Mersey valley. This is a remarkably fertile arable area with an almost complete absence, comparatively speaking, of permanent grassland. It is almost the only area in the west of England where wheat is an important crop, although the conditions are too damp for barley. Oats are also widely grown, but the depth and fertility of the soils available are especially shown in the remarkable concentration here of potato cultivation. Cattle are relatively few and sheep are practically absent.

(*c*) Cheshire and North Shropshire. The heavy soils of this region are largely under grass, and this is pre-eminently a great dairy-farming region, perhaps the most important in the British Isles. The farms are small, run by the farmer and his family, who under pre-1939 conditions often sold milk in the winter when prices were good, and in summer made cheese. Pigs are numerous and so are poultry. "C.C.C." (Choice Cheshire Cheese) became a famous branded product and the Caerphilly cheese was

a special type made for the Welsh mining districts. The great change wrought by the conditions of the Second World War was the ploughing up of a proportion of each farm for the production of home-grown fodder crops.

8. The Vale of York

This is in the main a tract of glacial drift, lake silts, and alluvium. It was formerly marshy, but is now well drained and extremely fertile. There is much land under pasture, but this may be described as one of the northernmost important arable areas in England. It is certainly the northernmost area where wheat is a crop of first importance and large quantities of barley and oats are also grown. In addition many of the subsidiary crops of eastern England are also to be found here, for example, peas and beans. The deep fertile soils favour root crops, notably potatoes, turnips, swedes, mangolds, and sugar beet, with carrots on very light land. Cattle are numerous but sheep few. The Vale of York extends southwards so as to occupy the extreme north-western corner of the county of Lincoln in the district known as the Isle of Axholme. The region here merges southwards into the Vale of the Trent.

9. The Midlands of England

It is by no means simple to give a general account of the large triangle in the heart of England to which this name of the Midlands of England has been applied. The area under consideration lies east of the Welsh massif, south of the southern end of the Pennines, and may be described as bounded on the south-east by the first of the major scarps of the Jurassic rocks which cross England. The south-eastern boundary thus defined does not coincide with any one geological horizon, but with a physical feature which, though discontinuous, can be well seen on the ground. The large triangle so delineated includes the southern two-thirds of Staffordshire, practically the whole of the county of Warwick, the greater part, except the north-western corner, of Worcestershire, and stretches south-westwards to comprise the Vale of Evesham and the Vale of Gloucester which lies between the Welsh hills on the one hand and the remarkable scarp of the Cotswolds on the other. To the north-east it may be described as including the whole of the county of Leicestershire and a portion of western Rutland, as well as just the borders of Northamptonshire. It extends farther north-eastwards, so as to include the greater part of Nottinghamshire and the western fringe of Lincoln as far east as the scarp of Lincoln Edge, which passes northwards through Lincoln itself. In general terms this is an undulating plain with rather heavy clayey or marly soils derived for the most part from the Keuper Marls and from the clays of the lower part of the Jurassic series (especially the Lias)

or, more frequently, from the glacial drifts derived from them. This is, *par excellence*, grazing country and was, before 1939, almost entirely, over huge tracts, under permanent pasture. In the Middle Ages it is clear that considerable areas were ploughed, and many of the fields of to-day show the well-known ridge and furrow structure indicative of early attempts to drain the heavy soils. During the Second World War there were great changes. Mechanisation made it possible to plough the heavy land with ease and some very heavy crops, notably of wheat, resulted. But the heavy soils of the Midland plain are interrupted over considerable areas by the occurrence of tracts of different soil. The Keuper Sandstones afford some excellent loams and so do some of the sandy drifts. There are also areas where the Bunter Pebble Beds and Sandstone outcrop and where the soils are light. Much of this ground is rather infertile

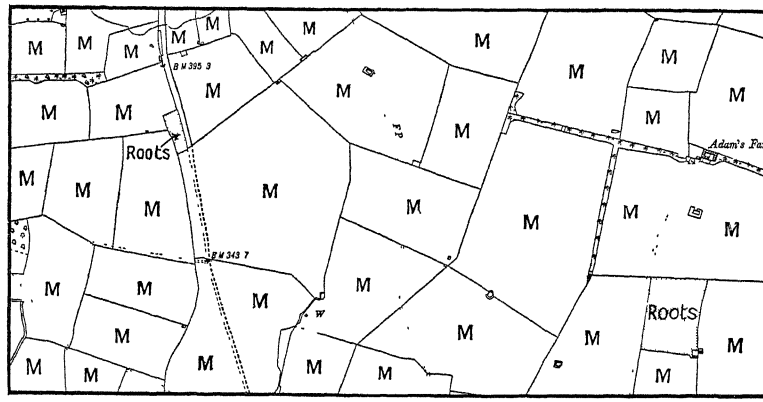


FIG. 126.—A section of country in the Midlands of England in 1932

Typical of farming economy in the damp Midland plains or the clay vales. The land is evenly divided into moderate sized fields, which before 1939 were nearly all under permanent grass, with a small field here and there devoted to root crops for winter feed. Scale, 4 inches to 1 mile. (By permission of the Ordnance Survey and of the Land Utilisation Survey of Britain) During the plough-up campaign of the Second World War, country of this type showed a greater change than anywhere in Britain and as much as 50 per cent. was ploughed

and is still covered with woodland, as, for example, the Sherwood Forest of Nottinghamshire. Then there are again hilly or upland areas formed by the outcrop of old rocks, such as Charnwood Forest. Finally, in the east, there is a tract of country occupying roughly the eastern half of Leicestershire, somewhat intermediate in character, between the Midland lowlands properly speaking and the hills of the scarplands. In this latter tract there is more arable farming, but considerable tracts of rather drier pastures suitable for large numbers of sheep—especially the famous Leicestershire breed. Lying just to the south on the borders of Northamptonshire is one of the best known centres for cattle feeding in England. These famous fattening pastures of the Melton Mowbray

to Market Harborough area are amazingly good—one bullock and one sheep per acre can be fattened and the great secret is close grazing. The cattle and sheep are purchased from March onwards and sold for killing from July onwards. In the winter this is a great fox-hunting country. Towards the south in the Vale of Evesham and in parts of Worcestershire soil conditions favour the extensive growth of orchards, and there is a closely associated vegetable cultivation.

10. North-East and East Yorkshire

The eastern part of the North Riding and most of the East Riding of Yorkshire fall clearly into four agricultural divisions:

(*a*) *Cleveland Hills and North York Moors.*—This is a plateau dissected by deep valleys. Rough hill pastures and moors occupy the higher parts of the hills; in the valleys there are considerable areas of pasture, but despite the position on the drier eastern side of Britain there is little cultivation owing largely to the prevalence of steep slopes and liability to floods on the low ground. A belt of arable coincides with the Corallian "tabular hills."

(*b*) *The Vale of Pickering.*—This remarkable basin once occupied by a lake now consists of well drained arable land reminiscent of Fenland. The position of the villages on the fringe is worthy of note; from them the central area is farmed.

(*c*) *The Yorkshire Wolds.*—Stretching in the form of a broad crescent from the Humber to Flamborough Head are the Yorkshire Wolds. The top of these hills is almost bare chalk, but the dip slope in the east is covered with varying thicknesses of chalky boulder-clay. Thanks to some early and far-seeing enclosure initiated by the Sykes family, the Wolds are cultivated all over, and it says much for the excellent farmers of this district that they can successfully cultivate on such a small thickness of soil. There is little permanent grass in this area, the whole of the farming depending on the Norfolk rotation with the folding of sheep (especially Leicesters) on the clover and the turnips and swedes; without this folding and its consequent manuring, agriculture would be far less efficient. "Downland" is non-existent.

(*d*) *Holderness.*—This lowland, covered with deep boulder-clay and patches of sand and gravel, has been drained with some difficulty and is in the main cultivated, the chief products being wheat, roots, and cattle.

11. Lincolnshire

The Lindsey District of Lincolnshire repeats the conditions found in the East Riding of Yorkshire. The Trent Vale in the west of the county is part of the Midlands of England and has the damp cattle pastures already described, though there are here considerable

areas under cultivation. Then comes the narrow Lincoln Edge, the prelude to the plateau surface, much more cultivated, of the Lincoln Heath, then the Vale of Lincolnshire—partly arable, partly grass—then the Lincolnshire Wolds which repeat the conditions found in the Yorkshire Wolds, and then the Lincolnshire Marshes along the coast which repeat the conditions found in Holderness, together with some wet pastures.

12. The Scarplands and Clay Vales

Stretching right across England from Lincolnshire (East Yorkshire having been separately considered), really from the neighbourhood of Lincoln itself to the Dorset coast, there is a series of discontinuous, west-facing scarps, accompanied by long, gentle, easterly dip-slopes (cf. pp. 45–50). The uplands are built of limestones, calcareous grits or sandstones, and the well drained higher levels are given over to arable land or to sheep pastures of short springy turf according to the relative fertility of the soil. This is a land of mellow stone villages, the stone houses often with roofs of thin stone slabs.[1] As one passes southwards and eastwards so the hills fade gradually into the Great Clay Vale, which may be said to extend as far as the great ridge of the chalk. This vale runs from the borders of the Fens on the north-east to the Dorset-Devon coast on the south-west; though south of the latitude of Bath the valley itself is ill defined. In places the main vale is interrupted by low ridges where harder rocks crop out at the surface, but on the whole it is a low-lying belt of clay giving rise to heavy soil. Permanent pasture and cattle rearing are the keynotes through the greater part of the area. This applies to much of the county of Northampton (except the mainly arable Ironstone belt with its rich red soils), the northern half of Buckinghamshire, the great central tract of Oxfordshire, and the north-western part of Wiltshire. The belt extends into the eastern and southern parts of Somerset and the neighbouring parts of Dorset and Devonshire. It is from these regions in the last-mentioned counties of Wiltshire, Somerset, and the borders of Dorset that much of London's milk is obtained, for it is pre-eminently a dairy farming country. The well known Wiltshire bacon indicates an important subsidiary industry. Returning to the north-east where the great clay vale abuts on the Fenland, there are large tracts covered with glacial deposits, particularly chalky boulder clay, affording excellent mixed soils, with the result that large areas in Huntingdonshire and the southern part of Cambridgeshire and Bedfordshire are arable land. Where heavy boulder clay occurs the land is poorer (notably in the western half of Huntingdonshire), where light loams result from the outcrop of

[1] Some of the best known used for this purpose are the "slates" of Collyweston and Stonesfield.

Lower Cretaceous sand or terrace gravels are the famous market gardens of Sandy and Biggleswade in south Bedfordshire.

13. The Fenlands

The once practically useless marshland known as the Fens has now been almost completely drained. The great work of reclaiming the pestilential swamps where, as on the Essex and other marshes, malaria was formerly rife, was begun in the 17th century with the help of Dutch engineers. Both the dark coloured mild peat soils of the drained fens and the silts of land reclaimed from the

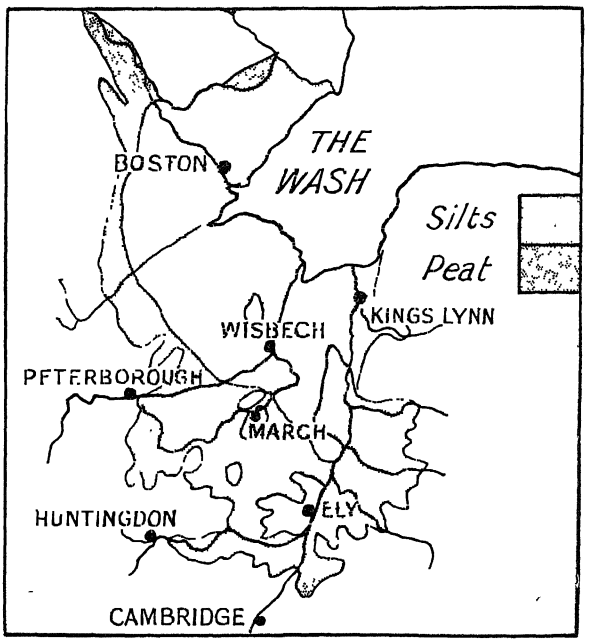


FIG. 127.—The Fenlands
Uncoloured areas are largely of boulder clay. Notice the boulder clay "islands"

Wash are amazingly fertile. This is undoubtedly the most intensely cultivated arable area in the British Isles. It comprises the whole of the Holland district of Lincolnshire and the whole of the Isle of Ely, together with the neighbouring parts of the Lindsey and Kesteven divisions of Lincolnshire and the fringe of Norfolk. More than three-quarters of the whole area is under the plough and amongst the great variety of crops grown are large quantities of wheat and sugar beet. Special mention may be made of potatoes (see p. 193), since this is the greatest area of potato cultivation in the British Isles, and of mustard for the factory at Norwich. The limited areas

of pasture are found especially on the old "islands" of boulder clay (see Fig. 127).

14. The Plain of Somerset

By way of contrast to the last area may be mentioned the Plain of Somerset, between the Mendips and the Blackdowns. Lying this time on the wetter side of England, it has not been so adequately drained, and is therefore still occupied by wet pastures, and parts

FIG. 128.—Peat-cutting in Somerset
Deep peat has been formed in many of the low-lying areas of Somerset

are liable to almost annual floods. The wet pastures afford excellent cattle country, especially along the Parrett. But there is magnificent arable land in the Vale of Taunton and the little Vale of Porlock.

15. The Chalk Lands of the South-East

The chalk lands comprise the well known North and South Downs, the great open downs of Dorset, Wiltshire and the northern part of Hampshire, and the stretch of chalk country forming the Chilterns and passing away into the East Anglian Heights. Farther to the north-east the chalk occurs over wide areas in East Anglia, but is so masked by glacial deposits that the land is entirely different in character. At least four types of land are found along the great Chalk Belt. First may be mentioned the huge tracts of arable land with a wide variety of crops. In the second place, where the land is not sufficiently good for ploughing or where the elevation is perhaps too great, the chalk instead is covered by short grass pastures affording that springy turf so characteristic of much of

the area. These short pastures are traditionally sheep pastures. In the old days the sheep fed by day on the grass, and at night were folded on the fallow arable land which they enriched with their manure. Later root crops were grown on the fallow for the sheep. Each region of the chalk evolved its own type of sheep—the South-downs and Wiltshires are examples, which when crossed gave the Hampshire Downs. In the third place, especially where there is a gravel coating, the chalk pastures may become rougher in character, gorse and bushes may appear. One gets, therefore, a proportion of rough pasture. It is land of this character which has been utilised

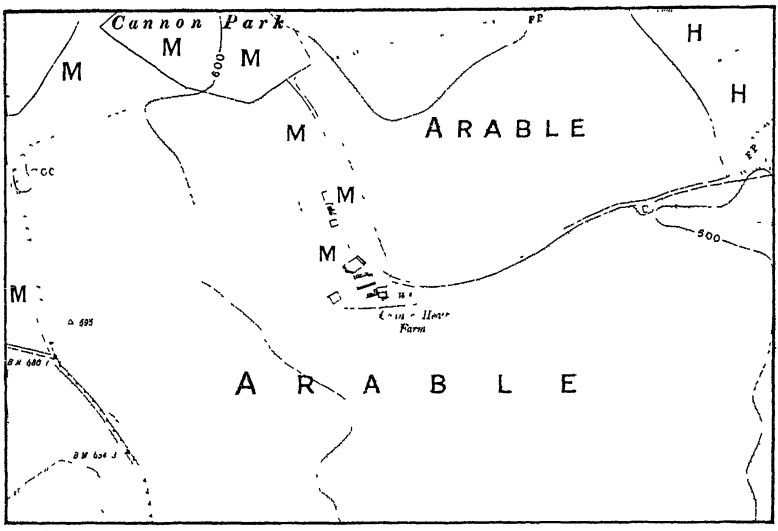


FIG. 129.—A section of country on the "downlands" of south-eastern England with huge open stretches of ploughed land, limited areas under pasture (M), and the poorer land left as rough pasture (H) for sheep. Scale, 4 inches to 1 mile

(By permission of the Ordnance Survey and of the Land Utilisation Survey of Britain)

for the military training grounds of Salisbury Plain. In the fourth place the surface of the chalk is frequently covered by a residual deposit known as clay with flints. This is a remarkably tenacious brown clay from which the lime has been almost entirely leached away; it frequently gives rise to patches of damp oak woodland, or where this has been cleared, to damp pastures supporting numbers of cattle—a remarkable contrast to the valley slopes on the actual chalk itself near at hand. Sheep kept on the short chalk pastures benefit the ground not only by their manure but by treading down the grass. It is found that the heavier cattle do this even more effectively, hence the evolution of sheep plus cattle farming. As it is no

longer economic to grow crops for sheep, the total numbers of animals tend to decrease and they are pastured rather on grass. During the Second World War large-scale mechanised ploughing converted much of the chalk land into waving fields of barley and other grains.

16. East Anglia

East Anglia, comprising the greater parts of the counties of Norfolk and Suffolk, as well as the northern two-thirds of Essex, may be described, broadly speaking, as a low plateau. Chalk occurs under a great deal of the area, but its characteristic feature is the wide mantle of glacial deposits. The surface utilisation and the type of farming depend upon the characters of the glacial deposits (see Fig. 130). The central belt is occupied by mixed loamy soils and is excellent arable country. Nearly half the arable land is under cereals: farmers on the lighter soils grow barley, on the heavier wheat. Formerly sheep were fed on swedes, and big Irish shorthorn bullocks fattened for Christmas. Now sugar-beet tops are used, and grass-fed lamb is important, whilst young bullocks are winter fed on roots and fattened on grass in summer. In the west where there are coarse sands occurs that huge infertile tract known as the Breckland now largely afforested with conifers planted by the Forestry Commission, whilst similar sandy and infertile tracts, the Suffolk sandlings, occur near the coast in the east. To the east of Norwich are the well known Norfolk Broads the origin of which has been much discussed though they occupy depressions at about sea level. On all heavier soils, dairying is spreading, the British Friesian cattle being very popular. The southern limit of this area coincides with the limit of the chalky boulder clay; farther south are the heavy lands on the London Clay itself.

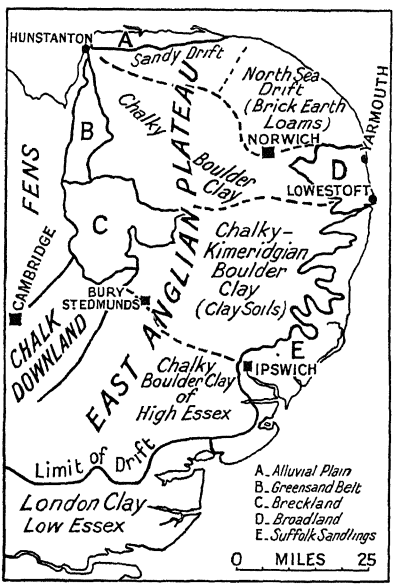


FIG. 130.—East Anglia

Agricultural regions (based on those suggested by Professor P. M. Roxby), with the East Anglian Plateau subdivided according to the character of the boulder clay (after maps by the late F. W. Harmer). Limit of Drift in Essex after S. W. Wooldridge and D. J. Smetham

17. The London Basin

Although a comparatively small area, the London Basin is agriculturally remarkably complex. At least four major types of land must be distinguished:

(*a*) The London Clay lands which give rise to belts of heavy soil covered with permanent pasture and utilised as cattle grazing areas. Many areas are still extensively wooded, *e.g.* Epping Forest, which was for many centuries a royal hunting ground.

(*b*) The sandy areas, more particularly the great Bagshot Sand plateau towards the west of the basin, giving extremely infertile coarse sandy soils occupied largely by heathland and pine woods.

(*c*) The belts of mixed soils, usually excellent loams, particularly conspicuous along the southern margin of the basin in north Kent. This is the great market gardening and fruit farming belt of Kent, supplying enormous quantities of fruit and vegetables to the metropolis, and important in the eastern part for its crop of hops.

(*d*) In the fourth place there are the stretches of brick-earth, terrace gravel, and alluvium which occur in the Thames Valley at different levels. The high level gravels may be overdrained and infertile, but the lower terraces, for example over much of Middlesex, afford excellent soils famous for market gardening and fruit (see Fig. 42).

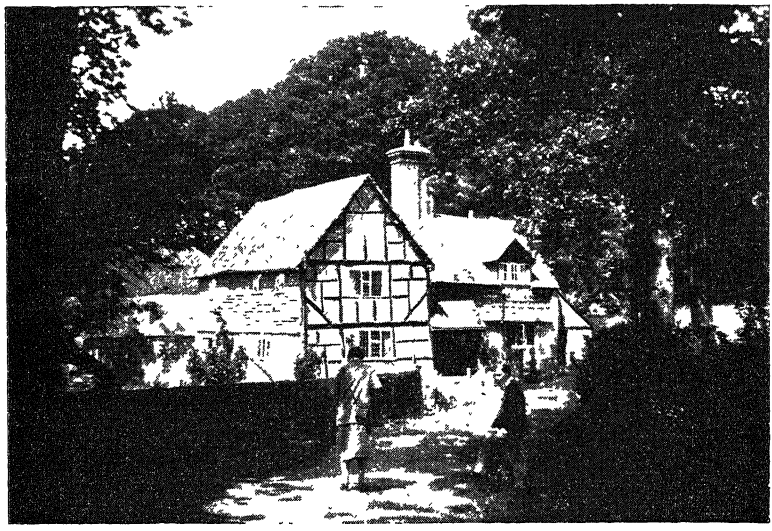
Unfortunately, London's housing has swamped much of the rural land, sprawling indifferently over good land and poor though recently Government policy has been to conserve some at least of the most productive land which remains.

18. The Hampshire Basin

In many respects the Hampshire Basin repeats the features seen in the London Basin. There are the heavy clay areas largely occupied by permanent pasture, the belt with mixed soil largely cultivated, the large tracts of barren sandy soil occupied in particular by the New Forest and, also extensive, the belts of gravel or alluvium. It should be noticed that both in the London and Hampshire Basins, as well as of course in the neighbouring parts of the chalk lands and in the Wealden belt, agricultural use depends very largely on economic conditions and the requirements of the metropolis.

19. The Weald

Inside the area defined by the North and South Downs there is that famous area the Weald. In the heart is a sandy area occupied largely by Ashdown Forest and tracts of heathland; towards the



[*Photo: L. D Stamp*

FIG. 131.—Timberscombe, near Fernhurst, Sussex

Typical of Tudor and Stuart domestic architecture in those parts of south-eastern England where timber abounded but stone was scarce—hence half-timbered brick work. This fine old house is now a guest house

margins are the sandy ridges of the Greensand of comparable character, including the wide stretches round Hindhead. Much of the rest of the Weald is occupied by the Weald Clay and other clay beds giving rise to a wet country, formerly covered with damp oakwood, but now cleared and occupied by pasture supporting numerous cattle. Round the fringe of the Weald in what is often called Holmesdale coinciding with the outcrop of the Gault, but on the better drained margins of which there is a belt of mixed soils excellent for cultivation. It is on some of the better soils in Kent that one finds the well known hop gardens and orchards. A small but important region within the Weald is Romney Marsh, now largely drained and used until 1939 curiously enough for sheep and not for cattle, being the home of the well known specialised Romney Marsh breed. In summer some tracts of this rich pasture land carry and fatten six or eight sheep and lambs per acre, in winter only the breeding ewes remain. It has now been found to yield soils as excellent for intensive cultivation as the Fens.

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CHAPTER XIII

THE BRITISH FISHERIES[1]

IN round figures the fisheries of the United Kingdom employ about 65,000 men, or in all give employment to double that number of people, so that, with dependants, approximately half a million of the population of the country depend upon this industry.[2] The annual catch is about a million tons, and the fishing fleet numbers over 12,000 vessels. According to FAO, the world production of sea-fish is 21,000,000 metric tons annually, so that Britain's share is about 5 per cent. of the world's total. So far as sea fishing is concerned, the British fisheries are possibly the most highly organised in the world, with the possible single exception of Japan. No country has so great a fleet of such large and powerful steam vessels for deep-sea fishing. On the other hand, the inland and freshwater fisheries are comparatively unimportant, with the exception of salmon which are still exploited commercially, especially in the rivers of Scotland and Ireland. River fishing in Britain is now mainly reserved for sport and recreation, whilst the waters of many a once-famous salmon or trout stream have become polluted and almost devoid of fish.

"Wet" fish, as distinct from shell-fish, fall into two main classes—pelagic and demersal. Pelagic fish, literally "ocean" fish, are those which live in the surface waters, feeding there on the immense numbers of plankton, or tiny organisms, the abundance or otherwise of which determines to a very large extent the size and the numbers of the fish. Pelagic fish tend to occur in large numbers or shoals, and by far the most important in the British fisheries is the herring. Others of importance are the pilchard and the mackerel. Although they are free swimming, these pelagic fish are by no means independent of the depth of the water or the character of the bottom, for they spawn on the floor of the sea. Demersal fish, known to the trade as "white" fish, are fish normally found feeding at the bottom of the sea, including both flat-fish such as plaice and sole as well as free-swimming fish such as cod and haddock. In pre-1914 years,

[1] We are indebted to Mr. J. H. Ray, Secretary of the British Trawlers' Federation, for help in the revision of this chapter.

[2] Number employed in fishing industry, 1921: England and Wales, 40,000; Scotland, 25,500. In 1931 the figures were 41,000 and 22,500. In 1951 36,882 fishermen were regularly employed and 5,039 occasionally employed in Great Britain.

owing to the enormous importance of the herring, roughly equal quantities of pelagic and demersal fish were landed at ports in the British Isles, although the value of the demersal was roughly double that of the pelagic. In the inter-war years both the quantity and value of the demersal fish became relatively much greater than those of the pelagic. In recent years this trend has continued, so that the weight of demersal fish landed is three or four times that of pelagic. The attached table shows the quantity and value of the two main types of fish of British taking landed at ports in England and Wales in recent years.

	Demersal		Pelagic		Total wet fish	
	Quantity cwts.	Value £	Quantity cwts.	Value £	Quantity cwts.	Value £
1925	9,287,404	11,956,516	4,246,575	2,263,299	13,537,475	14,224,682
1930	11,454,125	12,072,222	4,221,109	2,067,382	15,677,628	14,143,301
1933	10,941,278	10,186,857	2,722,148	1,002,814	13,663,426	11,189,671
1935	11,396,644	10,954,251	2,950,730	1,001,952	14,347,374	11,956,203
1938	12,644,600	11,300,925	2,882,105	928,786	15,532,692	12,233,209
1942	2,981,196	9,033,892	172,312	224,355	3,155,818	9,260,674
1948	11,915,308	31,205,439	2,524,018	2,601,907	14,439,999	33,809,691
1951	12,289,364	32,552,429	1,708,730	1,917,651	14,001,366	34,475,761

The totals in the last two columns include small quantities of unclassified fish.

Totals for Scotland were: 1925, £4,454,168; 1930, £4,177,775; 1933, £3,519,795; 1935, £3,852,112; 1938, £3,826,700; 1951, £10,858,500.

Although the fishing grounds visited by British vessels and from which fish are landed at British ports extend from Greenland, Iceland, Bear Island, and Spitsbergen on the north to Morocco on the south, and from the Barents Sea on the east to the west of Scotland, Rockall, and the south-west of Ireland, it is the character of the Continental shelf surrounding the British Isles themselves which must be regarded as in the main responsible for the rise to importance of the British fishing industry. The weight of the fish landed in Britain caught by the trawl, which can only be used in shallow water, has increased from about two-thirds in the inter-war years to over 87 per cent. in 1951. There is no trawling at a greater depth than 250 fathoms, that is 1,500 feet, and very little at a greater depth than 200 fathoms, or 1,200 feet, whilst a great deal of the trawling is carried out in water very much shallower than this. It will, therefore, be an advantage to study the submarine contours round the British Isles and to see what limits these place on the possible fishing grounds. It will be seen that the British Isles rest on a broad Continental shelf and are entirely surrounded by shallow water, as are Iceland, the Faeroes, and Rockall.[1] The North Sea,

[1] See A. H. W. Robinson, "The Floor of the British Seas," *Scot. Geog. Mag.*, 68, 1952, 64–79.

except for a deep channel off the coast of Norway, is everywhere less than 100 fathoms in depth. The northern part is 40–100 fathoms, but the southern half is everywhere less than 50 fathoms, or 300 feet. There is thus in the North Sea, on the whole, a gradual decrease in depth from north to south; but this gradual shallowing is interrupted by numerous banks and deeper depressions called pits. The largest and most important of the banks is the well-known Dogger Bank, which, with an area of something like 7,000 square miles, is covered by water only 10–20 fathoms deep. Not only do these shallow seas with their sandy or rock-free floors afford excellent fishing grounds where the trawl net can be used to the greatest advantage, but they also provide spawning and breeding grounds which are obviously essential to the maintenance of the supply of fish. Further, there is that absence of stagnation and monotony of conditions which might prove fatal. There are the movement of the tides round the British Isles and the warm drift of water from the North Atlantic drift, the seasonal variations in temperature, salinity, and the character of the bottom deposits which give the necessary variation of conditions for the different species of fish or to the same species of fish at different stages of development. The fish must depend ultimately for their supply of food on plankton. Plankton consist of (*a*) minute plants, particularly diatoms and algae, which, like land plants, are capable under the influence of light of transforming inorganic substances into organic material, thus rendering it available as fish food, together with (*b*) enormous numbers of small sea animals, such as small crustacea, hydrozoa, foraminifera, mollusca, etc., whilst together with the whole mass are huge quantities of the spawn of demersal fish. Indeed, it is the spawn of the demersal fish which suffer particularly from a paucity of plankton foodstuffs. A paucity of plankton means a heavy mortality amongst fish spawn, the effect of which will not be felt as far as the fisheries are concerned until some years later.

A map has been included to show the main fishing grounds from which landings of fish are provided for British ports. Each fishing boat, on arriving in port, is compelled to declare not only the type of fish caught but the area from which the fish has been obtained. For purposes of classification the Ministry of Agriculture and Fisheries has distinguished somewhat arbitrarily the fishing grounds which are marked on the map. As might be thought, easily the most important area is the North Sea, followed by the very important Iceland and Faeroes area, then by the distant grounds of the Barents Sea, Norwegian coasts, Bear Island, and Spitzbergen. The major change of recent years has been the increased importance of northern waters, including Greenland. Before examining the characteristic fish found in each of these areas it will be necessary to analyse the different types of fish landed.

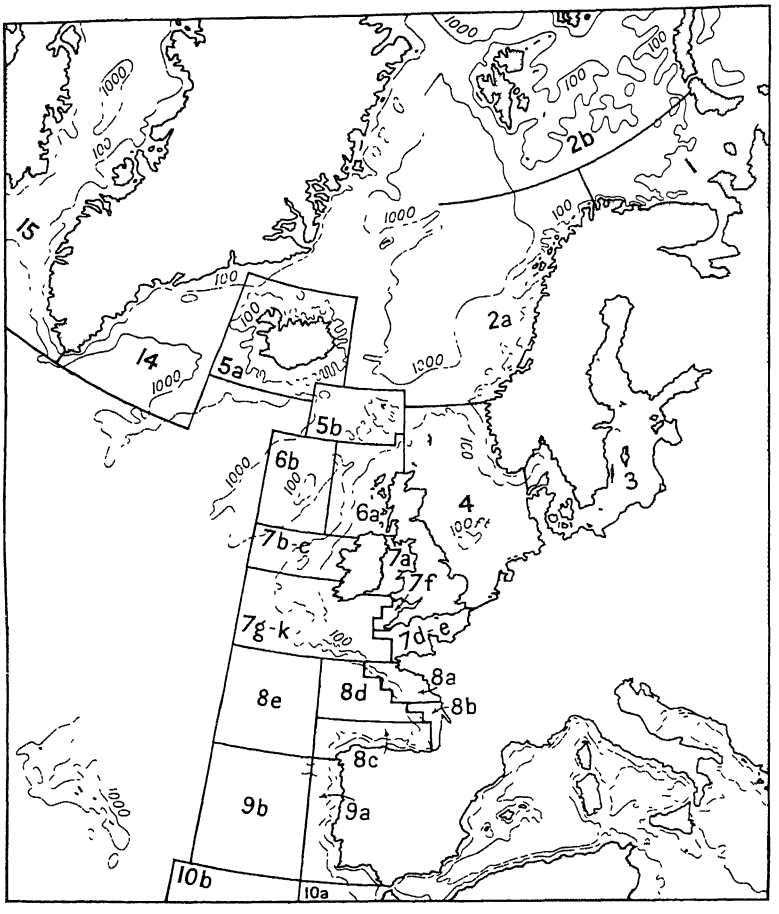


FIG. 132.—The main Fishing Grounds used by British fishermen

Depths are shown in metres (except the Dogger Bank)

1 Barents Sea and Murman Coast.
2*a* Norwegian Coast.
2*b* Bear Island and Spitzbergen.
3 Skagerak, Belts and Baltic.
4 North Sea. 5*a* Iceland. 5*b* Faroe.
6*a* West of Scotland. 6*b* Rockall.
7*a* Irish Sea. 7*b–c* West of Ireland
7*d–e* English Channel.
7*f* Bristol Channel.
7*g–k* South and South West of Ireland
8*a* S. Brittany.
8*b* French Biscay.
8*c* Spanish Biscay.
8*d* Biscay Deepwater.
8*e* West of Biscay.
9*a* Coast of Portugal.
9*b* West of Portuguese Coast.
10*a* Moroccan coast. 10*b* Madeira.
14 East Coast of Greenland
15 West Coast of Greenland

TABLE SHOWING THE VARIOUS FISH OF BRITISH TAKING LANDED AT BRITISH PORTS, 1937 AND 1951

Total weight landed at English, Welsh, and Scottish Ports (in thousands of cwts.)

Demersal Fish—	1937	1951
Prime fish—		
Brill	18	9
Sole	75	140
Turbot	71	56
Cod	7,513	7,442
Haddock	2,979	2 357
Whiting	495	947
Hake	601	484
Halibut	120	124
Plaice	599	564
Skate and Ray	429	387
Dogfish	201	254
Coalfish (Saithe)	664	639
Catfish	243	130

Pelagic Fish—	1937	1951
Herring	5,563	3,283
Mackerel	179	124
Pilchard	69	114
Sprats	150	87
All others (demersal and pelagic)	1,838	1,742
Total fish (excluding shellfish)	21,807	18,885

Value, £15,394,017 in 1937; £45,334,800 in 1951.
(Value of herring, £2,196,303 in 1937; £3,628,400 in 1951)
Shellfish, £540,346 in 1937. £1,175,800 in 1951.

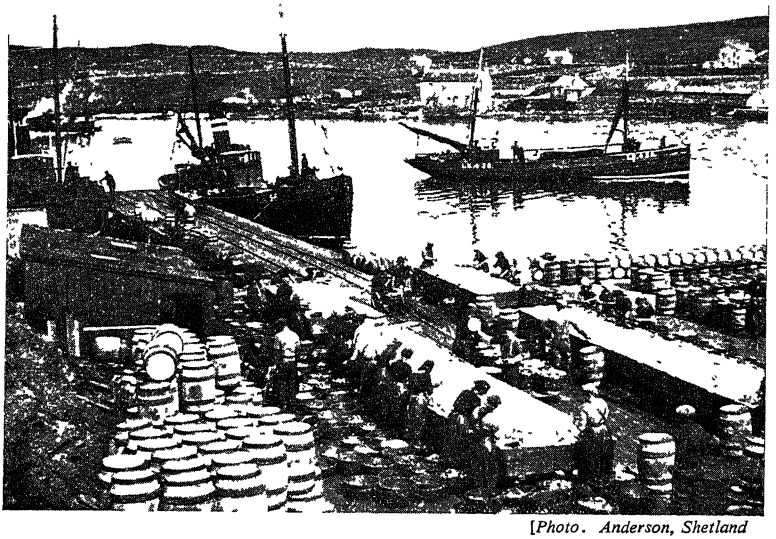
This table is at first very surprising, because it illustrates the fact that the fish which are most popular and best known on the British table or in British restaurants are actually landed in comparatively small quantities. This is partly because of the very large quantities of herring and cod and certain other fish which are absorbed by the export trade. Many of the fish with less familiar names are utilised by fried fish shops.

Returning now to the map of British fisheries we find that, taking the fish mentioned in the above table in order, they have certain characteristic features of distribution. The herring is characteristically, one might say exclusively, a North Sea fish. With the exception of the English Channel, southern Ireland, and the Bristol Channel, landings from other areas are small. Of other pelagic fish the once important pilchard almost disappeared but has been coming back. It is and always has been essentially a fish of the south-west of England, of the western part of the English Channel, and of the south of Ireland. The mackerel is again a southern fish, particularly important in the English Channel and the Bristol Channel. The sprat is another pelagic fish.

Turning to demersal fish, the cod is, of course, primarily a fish of cold northern waters. It accounts for about half the total landings of demersal fish, a large proportion from distant northern fisheries, and the quantity decreases as one comes southwards. The haddock is the predominant catch in the northern, deeper part of the North Sea. Halibut is still more a northern type, the really large catches being mainly restricted to Icelandic and other northern waters. Hake is unimportant in the North Sea but is the chief fish of the south-western area in the relatively deep trawling ground to the south of Ireland. Skate and sole are likewise the fish of the western side of England. Of the better-known flat-fish the plaice has the widest range. Landings from the far-distant Barents Sea area are important, but the popularity of the fish has given rise to anxiety because of the decrease in quantities which have been found in the

northern sea. The plaice and still more the sole are really the reason for the operation of British vessels in the more distant fisheries. The lemon sole and the widely appreciated turbot have never formed large percentages of the total landings. It should be noted that the more distant fishing grounds of Greenland, the White Sea, Barents Sea, Bear Island, and Spitzbergen represent a round trip of more than 3,000 miles from Grimsby.

Within the last half-century the British fishing industry has undergone a complete change. This may be summed up in the two words



[*Photo. Anderson, Shetland*

FIG. 133.—Lerwick, Shetland, at the height of the herring season

The three types of herring fishing vessels are shown—the steam drifter, the sailing-auxiliary motor vessel and, just visible in the background on the left, a sailing vessel

"centralisation" and "industrialisation." It is a commonplace of history that the British fishing grounds form a nursery for the seamen of both our Navy and our Merchant Navy. Almost every cove on the rock-girt coast of the west has its little break-water, its little quota of fishing-vessels, and, nestling in the sheltered valley behind, a little fishing village. The same is true of the sandy estuaries and coves along the eastern coast. In the days of the Armada these fishing villages provided the bulk of the sailors for the British Navy. The little old town of Fowey in Cornwall is proud of having provided no less than 47 ships for Edward III's navy for the siege of Calais, compared with London's 25. Less than 5 per cent. of the fish now

landed in the British Isles is landed at these small old fishing villages. Some of them, such as St. Ives, Mevagissey, or, to use its popular local name, "Fishygissy," and Brixham, choosing examples from the south-western peninsula, have done their utmost to fight the uneven fight against the octopus of the large railway fishing port. Others have discovered that there is a market value in picturesqueness and have come to rely for much of their revenue on their summer visitors. The fisherman hires out his boats for the summer months, while his wife provides board and lodging for the visitors. But unless the visitor's own skill is above the average he probably

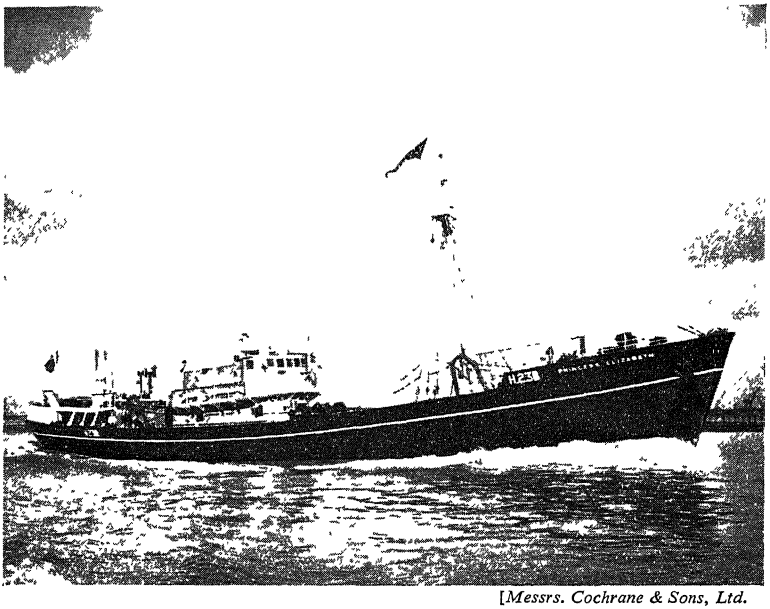
[*Photo Fox Photos*

FIG. 134.—The Aberdeen Fish Market, with fish laid out for sale by auction

finds that his stay at the seaside is marred by an absence of "fresh fish on the table." It is the advent of the steam trawler and the steam drifter which is in the main responsible for the great change.

The majority of the herrings and other pelagic fish are caught from the drifters and the majority of demersal or white fish from the trawlers. The drift-net carried by the drifters is lightly and strongly made of cotton, and each net measures from 50 to 60 yards long and about 13 yards deep, but the nets are used in a "fleet" or series, so that sometimes as many as eighty are employed at one time in one vessel, to form an extended wall of netting hanging perpendicularly in the water. There is a headline kept floating on the surface by a series of buoys or "pellets," and the top of the net is usually about three yards below the surface, being connected with the headline by a series of ropes called strops. The net or nets are attached to the floating buoy or to the drifting ship itself, hence the name "drifter,"

and move with the buoy or ship under the influence of wind and tide. The net is arranged to intercept fish of the right size which attempt to pass through and are caught by the gills. Thus drift-nets are of different gauge according to the fish it is proposed to catch. Those for herring have an inch mesh, a smaller size are the drift-nets used for catching sprats, while drift-nets of a larger size are used elsewhere for catching salmon. A few wooden drifters are still in existence, but the majority are of steel. Drifters are not large and for long the majority in Britain were about the same size, having a gross tonnage of 95 and a length of 85½ feet, and a beam of 18½ feet, carrying a crew of seven men and a boy.



[*Messrs. Cochrane & Sons, Ltd.*

FIG. 135.—A Modern British-built Deep-sea Trawler

The most important method of fishing demersal fish is by trawling. In 1951 87 per cent. of all fish landed in the United Kingdom by British fishing vessels was caught by trawlers. The trawl-net is a bag-shaped net, the mouth of which is kept open either by a beam across the head or by pressure of the water upon wooden kites known as trawl-boards, or trawl doors, attached to the net. The beam-trawl is still used but only on fishing smacks and small vessels. The ordinary modern trawl-net is towed about 200 yards astern; the trawl runs along the sea bed where the fish feed. Wooden or metal "bobbins" are attached to the lower part of the mouth and act as wheels, enabling the trawl to be pulled more readily and with less risk of damage over rocks and other irregularities. Floats are

attached to the upper part of the mouth. The trawl is drawn in by winches about every two hours. The fish poured out on the deck are immediately sorted, cleaned, and packed in the ship's fish-rooms. There they are laid out, as far as possible, on ice-lined shelves so that no weight presses on them. The steam trawlers built in Britain after the First World War tended to conform closely to three types: the large "Mersey" type, the medium-sized "Castle" type, and the smaller "Strath" type.

It is now usual to divide Britain's trawlers into two fleets—the near-water fleet and the distant-water fleet—and the vessels are classified by length. Distant-water vessels are in many cases 200 feet in length, driven by steam engines using oil fuel and with a crew of about 20. They are fitted with modern aids to navigation —radar, echo-sounders, and wireless. In the near-water fleet, especially that operating in the North Sea, the smaller vessel driven by diesel engines is gaining in popularity, and North Sea trawlers are usually fitted with Decca navigators.

The annexed table shows the distribution of trawlers by size and illustrates the concentration of the large distant-water fleet on Hull and Grimsby. Some of the fishing grounds are 1,500 miles away, and an average voyage is about three weeks, compared with eight or nine days for the near-water fleet. The introduction of quick-freezing or deep-freezing may lengthen the voyages. Another

DISTRIBUTION OF TRAWLERS BY PORTS ON DECEMBER 31, 1951 [1]

Port	Length 70 ft. to 129 ft.	Length 130 ft. to 140 ft.	Length Over 140 ft.	Total
North Shields	41	—	—	41
Hartlepool	6	—	—	6
Scarborough	3	—	—	3
Hull	—	4	163	167
Grimsby	139	6	91	236
Lowestoft	120	—	—	120
Yarmouth	10	—	—	10
Ramsgate	2	—	—	2
Poole	1	—	—	1
Brixham	8	—	—	8
Newlyn	5	—	—	5
Plymouth	4	—	—	4
Cardiff	2	8	—	10
Swansea	7	3	3	13
Milford Haven	71	9	8	88
Fleetwood	80	22	23	125
Aberdeen	199	11	3	213
Montrose	3	—	—	3
Leith	39	14	1	54
	740	77	292	1,109

[1] Extract from White Fish Authority First Annual Report and Accounts for the Period Ended March 31, 1952.

modern feature is the elimination of waste—some trawlers are being developed as "factories" making cod liver oil and fish meal at sea.

There are a few subsidiary but still important methods for fishing employed in the British fisheries. One is fishing by line—a line of baited hooks. This is mainly used by Scottish fishermen in the northern part of the North Sea. The other method is that of the Danish *Seine* net. Fishing by this net was perfected by the Danes during the First World War and its adoption to any considerable extent in England only dates from 1921. It was the direct result of Danish boats putting into British ports and British fishermen having evidence placed before them of the efficiency of a new method. The trawler actually drags the net along the bottom, but in this method of fishing the vessel remains stationary whilst the bag-shaped net is at the centre of a very long haulage line and is gradually hauled in by a motor-engine on the vessel, there being an arrangement of ropes in front of the net in such a way that they rather disturb the fish lying in the path of the net and cause them to move in such a way as to get caught. It has grown greatly in importance in Scotland. Lining is mainly used for large fish, particularly cod and halibut, and the baits used vary according to the season—mussels, whelks, small herring, etc.

The table given on the following page shows the quantities of fish caught by each of the principal methods and landed at British ports.

Although the trawl-net has been in use in British fisheries for something like 250 years, until 1870 it was in the form of the beam-trawl and was operated exclusively by sailing-vessels. The sailing-vessels could not be absent more than a few days from port; they were largely dependent upon weather conditions; the radius within which they could fish was distinctly limited. Of necessity they landed their fish at the nearest available port, probably their home-port. Steam-power was first introduced in the form of tugs, which assisted these fishing-vessels, but the gradual evolution of the steam trawler followed. It is interesting to notice that these trawlers are built at special shipbuilding yards, not as a rule at the ordinary ship-building centres. A very large number are either built or assembled at ports surrounding the Humber, such as Beverley, Goole, and Selby.

The next map (Fig. 136) will show at a glance the principal fishing ports of Great Britain. Against each of the ports there have been shown the landings for 1951. It will be seen how from the modern industry there have disappeared once important fishing ports such as Stornoway in the Outer Hebrides and Lerwick in Shetland. The industry is now concentrated on five of the ports on the east coast of Britain and one, Fleetwood, on the west coast.

Not only is there a concentration of the British fishing industry at certain leading ports, but there is a distinct specialisation at each of

QUANTITY OF WET FISH OF BRITISH TAKING LANDED

	1913 cwts.	1921–1925 (average) cwts.	1926–1930 (average) cwts.	1951 cwts.
1st class—				
Trawl, steam	7,991,404	7,665,800	8,868,334	11,092,011
,, motor	909	21,483	24,594	290,691
,, sail	418,269	165,600	127,850	—
Total	8,410,582	7,852,883	9,020,778	11,382,702
Lines, steam	281,185	360,584	301,001	24,219
,, motor	14,886	50,896	93,102	4,417
,, sail	18,720	—	—	—
Total	314,791	411,480	394,103	28,636
Danish seine, steam	—	287,097	160,724	2,263
,, motor	—	7,570	6,564	124,610
Total	—	294,667	167,288	126,873
Drift, steam	6,402,729	3,020,433	3,551,427	1,700,952
,, motor	209,296	346,866	275,069	1,192,144
,, sail	306,784	340	69	—
Total	6,918,809	3,367,639	3,826,565	2,893,096
Other methods and methods not known	17,051	22,906	24,472	503,638
2nd and 3rd class, and from shore	464,202	463,488	364,892	217,766

the ports. Those that have the largest landings of pelagic fish, *i.e.* mainly herring, often show a comparatively small importance in relation to demersal fish and *vice versa*. The reason for this will be apparent if we make a brief study of the herring industry. An outstanding feature of the herring industry is the large proportion of the catch which is destined for export. Before the First World War as much as 75 per cent. of the total catch was actually exported, mainly to the Baltic countries and Russia. Even now a considerable proportion of the herrings is exported. Of the remainder, a comparatively small proportion is destined for consumption in this country as fresh herrings, more being destined for home consumption as bloaters and kippers. Thus, in the case of herrings, when they are landed there is not usually the need for rapid distribution to consuming centres that there is in the case of demersal fish. Instead, there must be provision for the salting of the herrings in barrels, and often the manufacture of the barrels themselves takes place, as at Yarmouth, near the actual landing-places of the fish. Bloaters are herrings which have been lightly smoked; kippers are herrings

which have been cut open and gutted and smoked, usually with the help of a wood-fire. The lightly smoked bloaters do not keep so long as the kippers, but at the same time there is not the need for haste in their distribution to markets and consuming centres.

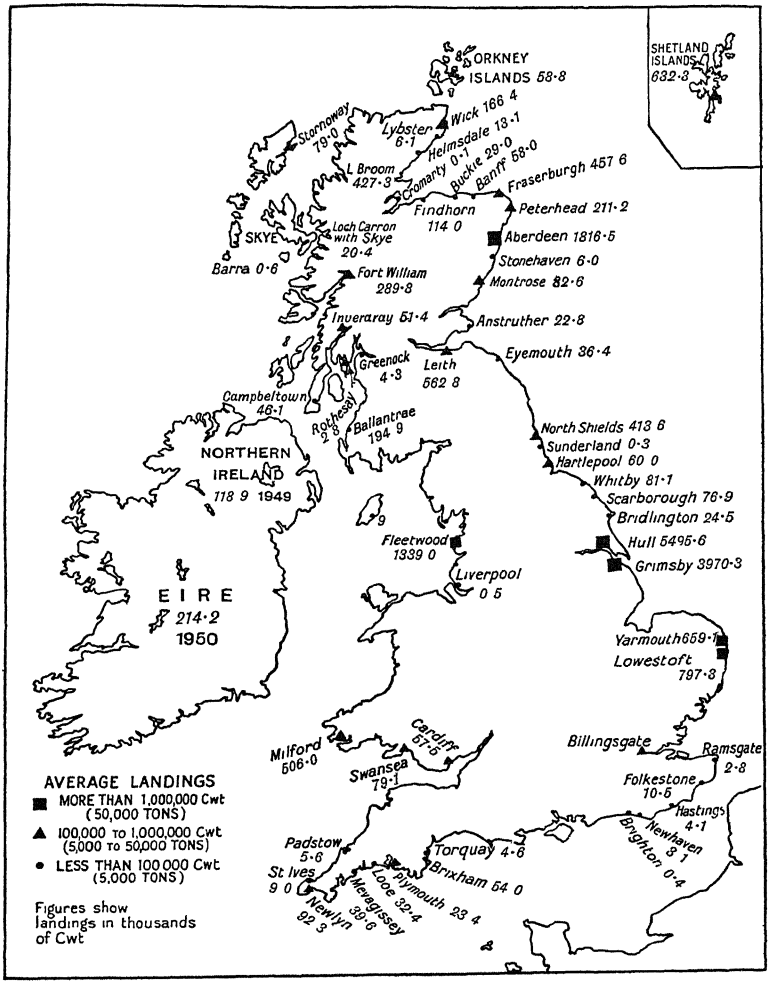


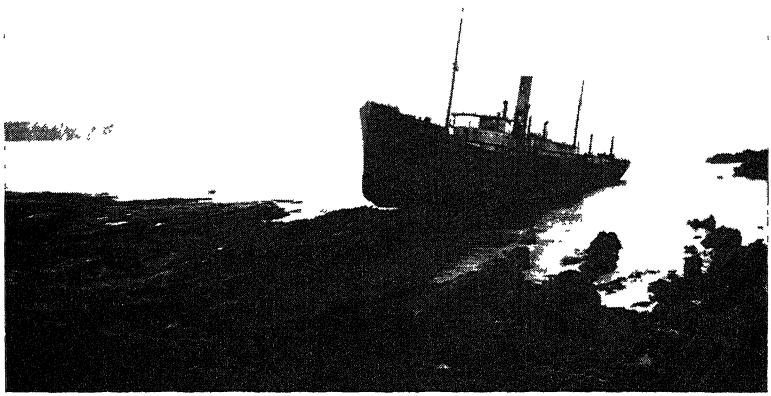
FIG. 136.—The fishing ports of Great Britain

Figures are landings for the year 1951

Important Note The names refer to fishing *districts*. In some cases, *e.g.* Montrose, much of the actual landing is at a neighbouring unnamed port (*e.g.* Dundee)

Turning to the list of the great herring ports of Scotland we find, in order, Frazerburgh and Peterhead, to the north of Aberdeen, not nearly so conveniently situated relative to rail transport as Aberdeen itself. Then there is Wick in Caithness, too far to the

north of the country to be suitably situated for the landing of demersal fish. Of the three herring ports on islands, Stornoway in the Outer Hebrides, Stromness in Orkney, and Lerwick in Shetland have practically no trade in demersal fish for British markets. In England, Yarmouth is pre-eminently the herring port, with Lowestoft a good second, landings at other ports being comparatively small. The second interesting feature about the herring industry is its seasonal character. The fishing starts about June in the north and terminates about October or November in the south at Yarmouth. It is a mistake to think that the fish themselves migrate southwards. The herring fishing in Devon and Cornwall is still



[*Photo: L. D. Stamp*

FIG. 137.—A wreck on the northern shores of Scotland

The Pentland Firth, between John o' Groats and the Orkney Islands, is one of the most treacherous tracts of water in the world

later, though not an important amount, being in December. It would seem that the time of spawning of the herring is determined by the physical conditions of the water, and takes place much earlier in the north than in the south, so that the herring are ready for catching earlier in the north than in the south. Although the herring themselves do not migrate southwards, the fishing boats to a very large extent do, and so also do the Scottish fisher-girls who are engaged in cleaning the fish and packing them in barrels or preparing them for kippers and bloaters when they are landed.

During the season in the heyday of the industry as many as a thousand boats might have been out from Yarmouth and a day's catch 4,000 tons, or three-quarters of a herring for every man,

woman, and child in the British Isles, although present-day landings are much smaller. Although nutritively far more valuable than equal quantities of white fish, the herring, probably because of its commonness and cheapness, is not fully appreciated in this country. It is not, indeed, appreciated nearly as much as it should be.

After being cleaned the herrings for export are packed in barrels in alternating layers of salt and fish. Some of the brine is drained off before the barrels are sealed for export. The herrings go especially to Catholic countries, but the former huge trade to Baltic ports is almost a thing of the past.

Turning now to demersal fish, the overwhelming importance of the Humber ports Hull and Grimsby in England, paralleled to some extent by Fleetwood on the west coast, and Aberdeen in Scotland, is at once apparent. There is an important trade in the buying and salting of cod for export, particularly to southern Europe and

TOTAL WEIGHT OF DEMERSAL FISH LANDED IN ENGLAND, WALES, AND SCOTLAND BY BRITISH FISHING VESSELS FROM THE PRINCIPAL FISHING GROUNDS, 1951

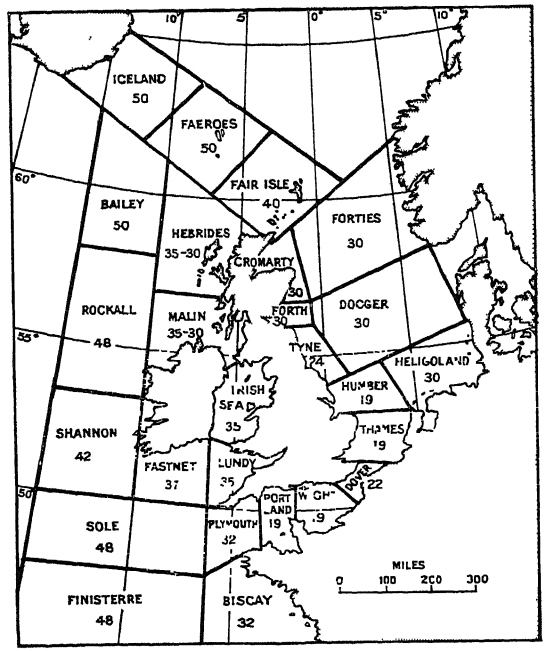
	Tons
Barents Sea and Murman Coast, Norwegian Coast, Bear Island and Spitzbergen, West Coast of Greenland	285,540
North Sea	126,000
Iceland	141,500
Faeroes	54,700
Western Areas of England, Wales, and Scotland (inc. English Channel)	84,460
Total	728,200

MAIN DEEP SEA TRAWLER FISHING PORTS OF THE UNITED KINGDOM

Landings of Demersal Fish at the Major Fishing Ports in 1951		No. of trawlers as at 31/12/51
	Tons	
Aberdeen	79,700	213
Newhaven and Granton	26,600	54
North Shields	12,300	41
Hull	275,000	167
Grimsby	198,000	236
Lowestoft	15,300	120
Milford, Cardiff, and Swansea	30,100	111
Fleetwood	66,000	125
Total	703,000	1,067

It will be noted that the landings of demersal fish at these ports amount to almost the total weight of demersal fish landed in the United Kingdom.

other Roman Catholic countries, but the bulk of the remainder of the demersal fish is destined for home consumption. Whilst it keeps comparatively well with the help of salt at the even temperature in the holds of the vessels from which it has been caught, as soon as the fish is landed deterioration is rapid. Though processes of freezing fish have now been perfected, they are expensive and if possible must, therefore, be avoided. Further, freezing, although it does not destroy the nutritive value of the fish sometimes tends to destroy the flavour. Thus there is evidence at once of the necessity



[*By permission of the British Trawlers Federation*

FIG. 138.—The Standard Weather Report Areas around the British Isles

An important service to fishermen is the daily broadcast by the B B C of weather forecasts for each area shown on this map. The figures indicate the average annual number of days with gale in each area

of very rapid handling as soon as the fish can be landed, hence the very specialised type of water-side accommodation, railway sidings by the wharf, special fish expresses running during the night and reaching the great markets, such as London, in the early hours of the morning. The great fishing ports are, in other words, the creation of the railways. An excellent example of what facilities and handling and transport mean to the fish trade is afforded by Fleetwood. A few decades ago Fleetwood had a small passenger traffic to Ireland. The London, Midland, and Scottish Railway quite

definitely decided on the policy of abandoning the passenger traffic and of concentrating all their attention on improving the facilities for the landing and the handling of fish. The result is seen at once in the figures: in 1913 Fleetwood handled 745,632 cwt. of fish; in 1935 it handled 1,230,000 cwt. Now Fleetwood may be said to attract fishing vessels from right away to the south of Ireland, and as far as lonely Rockall to the west of Scotland, merely because of the facilities which have been provided for rapid handling. It has not, however, stood up against the competition of Hull and Grimsby. The specialised organisation of some of the fish-markets, including that of Billingsgate, will be noticed later. It should be mentioned that fishing for demersal fish is not seasonal in character like that for herrings, but takes place throughout the year.

The trade in fish and fish-products of the United Kingdom is interesting. The bare figures are given in the table below:

	1927 tons	1929 tons	1931 tons	1935 tons	1951 tons
Imports (fresh, cured, canned)	242,000	263,000	229,000	194,000	186,750
Exports of United Kingdom produce (fresh, cured, salted, canned)	384,000	414,000	272,000	229,000	63,500
Exports of United Kingdom (cured or canned herrings only)	274,000	302,000	184,000	—	39,610
Re-exports (cured or canned fish of foreign and colonial origin)	19,000	23,000	15,000	8,000	622

The bulk of the exports is represented by herring and cod, a very large proportion of the imports by canned salmon and sardines.

Provision for fishery research is made by the Ministry of Agriculture and Fisheries for England and Wales, and by the Fishery Board for Scotland. No historian needs to be reminded of the consequences of the medieval migration of the herrings when they left the Baltic Sea, and this should be a reminder that the habits and peculiarities of fish should be watched and understood. Despite the fact that fish are extraordinarily prolific creatures the fishing year after year must of necessity tend to deplete the fisheries. That this has happened and is happening is quite evident from the figures of North Sea catches. It is evident in another way. During the two world wars the North Sea fisheries had a considerable, almost a complete, rest, and when fishing recommenced in 1919 and 1946 the hauls were remarkable for their size but in the next two or three years rapidly dropped again. This shows the effect of resting a fishery. Much can be done, too, by hatching out spawn and then distributing the young fish in suitable places on the sea bottom.

Much hatching of spawn, of course, is now carried out in the salmon fisheries of North America. A peculiar position arises with regard to soles and plaice in the North Sea, which spawn in the southern part of the North Sea, and possibly owing to drifting currents the young fish find their way north-eastwards towards the coast of Denmark. It would seem that they are unable, owing to intervening deeper water, to reach the more suitable feeding grounds which are on the Dogger Bank. If these spawn or young fish can be taken and transported and dropped on the Dogger Bank it is found that they grow with most amazing rapidity. This is quoted as one example of what may be done towards the maintenance or development of British fisheries. Amongst the institutions for studying these problems may be mentioned the Marine Biological Station at Plymouth and the Fisheries Laboratory at Lowestoft.

Shell-Fish.—It remains now to deal with what are usually called shell-fish despite the fact that they are biologically unconnected with fish at all. Shell-fish used for human consumption belong biologically to two main groups—the mollusca (including both bivalves and univalves, or gastropods) and crustacea. The bivalve molluscs include the important oyster and the very common though little-used mussel and cockle and the large scallop. Round the coasts of Britain are many molluscs either closely allied or identical with those designated clams in America, but they are rarely used for food. The chief gastropods are the whelk and winkle. The crustaceans include lobsters, crabs, prawns, and shrimps, with small quantities of crawfish.

The value of shell-fish on an average in the inter-war years was about £500,000. Although there were difficulties, especially of labour and restrictions on access in such areas as the Thames mouth, value was maintained at roughly this figure through the war. In value four items tie for first place—oysters, lobsters, crabs, and shrimps.

In pre-1939 days oysters (*Ostrea edulis*) were easily the most valuable shell-fish and in the early part of the present century production in Britain was probably nearly 50,000,000 a year—many times the figure for recent years. The great oyster beds for which this country has long been famous are concentrated on either side of the mouth of the Thames—particularly on the mud flats off Whitstable, Kent, and on similar mud flats in the neighbourhood of Colchester, Essex. The summer is the spawning season and so a "close-season" when fishing is prohibited. Actually the oysters at that season are not, in any case, at their best for eating, hence the old rule that oysters should only be eaten when there is an "r" in the month—that is from September to April. The opening of the fishing season is usually celebrated by some picturesque ceremony as

when the mayor of Whitstable eats the first "native." After benefiting from a war-time rest, the Whitstable beds suffered severely in the winter of 1946–47 when the shallow sea froze. Formerly the estuary of the Fal had important oyster beds: of recent years the oysters of the Helford River, also in Cornwall, have achieved considerable popularity.

Mussels (*Mytilus edulis*) occur widely round the coasts, adhering to rocks and submerged objects, but are only consumed in small quantities—by gourmets as a constituent in fish sauces and by those who still appreciate the little plates of shell-fish sold from barrows which were once a major feature in the poorer districts of London. Cockles (*Cardium edule*) from sandy shores, the large whelks (*Buccinum undatum*), and small periwinkles or winkles (*Littorina littorea*) to be extracted from their shells with a large pin were also a feature of the itinerant barrow. The large scallop, or escallop (*Pecten opercularis*), is taken from depths of 5–20 fathoms on a sea-floor of shell fragments as in the Irish Sea, off Weymouth, or in the Firth of Forth. Oysters are rarely cooked in Britain, all the others are normally cooked before eating.

Of the crustaceans which are caught for human consumption, shrimps (*Crangon vulgaris*) favour shallow water over a sandy bottom and are caught in large numbers in the Wash and Morecambe Bay. It used to be a common sight to see men wading in the shallow waters, walking parallel to the shore and pushing a large shrimping net before them. The large prawn (*Leander serratus*) is more local and favours rocky shores where it hides in rock crevices. The aristocratic lobster (*Homarus gammarus*) has long been a highly esteemed delicacy and gives rise to important fisheries. It lives in shallow water but where there are numerous submerged rocks in the joints of which it finds shelter and is caught by lowering lobster "pots"—wicker baskets weighted with a stone and bated with pieces of stale fish. The aperture is so arranged at the top that the lobster gets in but cannot find the way out. The Channel Islands, the rocky coasts of the south-west in Devon and Cornwall, the Orkneys and Stornoway in the Hebrides are all famous for lobsters. Indeed, in the south-west, many of the small fishing villages rely now almost entirely on their lobster fisheries (apart from summer visitors), the regular fishing having moved to larger ports. The Norway lobster (*Nephrops norvegicus*) is smaller and has long, slender claws. It lives in deeper water and is hence caught, incidentally, by trawlers. The sea-crawfish, or rock lobster (*Palinurus vulgaris*), has no pincers but long thick antennae and a spiny shell. It is found on the northern coasts.

Crabs (*Cancer pagurus*) are somewhat localised in their distribution and come especially from the North Sea—with landings at Flamborough and Scarborough long well known.

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CHAPTER XIV

COAL

THE value of the output of the mining industries of the United Kingdom, relative to the other great branches of industry, is considered in Chapter XXXII, and of recent years the coal mining industry has been too much before the public eye for it to be necessary to stress its importance in this country. What is not always realised, however, is the overwhelming pre-eminence of coal amongst British minerals as a whole. In the inter-war years coal represented nearly 90 per cent. by value of all the mineral products of the United Kingdom. By contrast the next in order of value represented less than 2 per cent. Similarly at the 1948 Census of Production coal represented over 90 per cent. by value of all minerals.

Britain has ceased to be to any degree a producer of metallic ore minerals other than iron; all the other minerals of which the annual value is over £1,000,000 are non-metallic. Of the metalliferous minerals for which Britain was once famous, tin ore and lead ore are the only ones of any considerable value.

Mineral	Production 1931–1935		Production 1950	
	Million tons	£mn.	Million tons	£mn. (1948)
Coal	215·6	141·5	216·3	365·7
Iron ore	8·8	1·9	12·9	
Chalk	10·4	—	12·9	
Limestone	13·9	2 9	24·3	
Igneous rocks	9·8	3·0	11·1	
Slate	0·3	1·6	0·2	1 9
Sandstone	4·1	1·6	3·0	
Salt	2·3	1·1	4·2	3 7
Clay, shale, etc.	19·1	1·7	23·1	
China clay	0·8	0·8	0·8	
Potter's clay	0·2	—	0 4	
Fireclay	1·9	0 6	2·2	
Gravel and sand	12·0	1·8	38·8	
Oil shale	1·5	0·4	1·5	
Tin ore	0·002	0·3	0·001	
Moulding sand	0·8		0·7	
Ganister	0·6		0·5	
Gypsum	1·1		2·2	
Others	—	1·6	—	28·1
Total		160 8		402·6

The same predominating importance of coal mining is borne out

if one considers the employment figures. The following table shows the numbers employed in the principal branches of the mining industry according to the Census of Production, 1948, and in some previous years:

	1927	1935	1948
Coal mines	1,023,886	769,474	727,565
Iron ore mines and quarries	11,864	7,981	6,529
Other metalliferous mines	5,137	3,409	
Salt works	97,399	84,100	4,824
Slate quarries			4,724
Other non-metalliferous mines and quarries			39,133

Not including clerical and other non-operative staff.

It is a commonplace to say that Britain's industrial development has been based on coal. The statement is true not only of the past, but remains true at the present day. Britain's whole prosperity depends essentially on her ability to obtain the coal that still exists in quantity in her coal fields. The difficulties in which the coal industry finds itself after the Second World War are widely misunderstood, and the mistaken belief has gained unfortunate currency that the chief difficulty is the exhaustion of the reserves—which is, happily, far from the truth.

Coal has been worked in Britain since very early times. The discovery of coal cinders in the ruins of Roman towns makes it probable that the Romans used coal during their occupation of the country. The "Anglo-Saxon Chronicle" records its use in monasteries in the ninth century. By the thirteenth or fourteenth century there was a well-established trade in sea-borne coal from Newcastle and Tyneside to London. The early workings were naturally along outcrops, but coal at or near the surface is apt to be badly weathered and unobtainable in lumps suitable for transport and burning, so that commonly a seam was followed from a scarp-face outcrop into the hill by means of adit or drift. Such outcrop workings were abandoned when water caused difficulties or the roof collapsed, and their place was taken by shallow mines, from which the coal was removed by haulage up a shaft. As a rule, no records were kept either of outcrop workings or of the early mines, with the result that many seams near the surface are honeycombed with irregular excavations. Much coal remains, but any attempt at more systematic exploitation by modern methods is likely to reveal old flooded workings, and the amount of coal still available is unknown.

In general terms the story of development is the same for all the British coal fields, though they may be in different stages at the present time. There was first the spasmodic local working in open

pits or shallow mines; then came shaft mines and colliery villages and towns and the growth of factory industry, with all the attendant network of services and communication—the improvement of roads or construction of tramways, later the extensive building of canals, rendered obsolete by the advent of railroads. The industrial regions took on the high degree of specialisation characteristic of Britain—Lancashire with cottons, the Leeds-Bradford area of Yorkshire with woollens, the Sheffield area with iron, steel, and cutlery, the Black Country with iron smelting, and so on.

But coal winning is a robber industry, and in due course the available coal becomes worked out. In Britain this has happened, in part at least, in the old Black Country of southern Staffordshire and neighbouring parts of Worcestershire. In most of the fields, however, only the more accessible seams in the shallow parts have been exhausted; workings have become concentrated in the deeper parts, often in the "concealed" fields, where large units and large-scale organisation are both essential. The Report of the Royal Commission on the Coal Industry (1925) demonstrated most realistically that in every British coal field there were large, modern, well-equipped collieries producing coal at competitive prices and small, old, uneconomic collieries whose costs of production were much higher. Out of 114 undertakings that in 1926 were operating at a loss of 3 shillings a ton or more, no fewer than 110 had a yearly output of less than 400,000 tons.

NATIONALISATION AND THE MANPOWER PROBLEM

At first thought the obvious course would seem to be to shut down all the old, uneconomic collieries and concentrate on the large, modern ones. But this would involve destroying the *raison d'être* of the well-established towns in all the older coal-field areas. The government consequently instructed colliery owners to carry out voluntarily a grouping of collieries so that the large modern units could each carry a share of the old small units. Where this "rationalisation" was not done voluntarily, it was done compulsorily. It may be asserted that this was a prelude to the several steps to nationalisation that followed. The coal resources of the country were made the property of the state by the Coal Act 1938 (effective from 1942), but it was left to the Labour Government, elected in the summer of 1945, to nationalise the industry itself. The Coal Industry Nationalisation Bill was introduced on December 19, 1945, passed through all stages in both houses, and received the Royal Assent on July 12, 1946. It established a National Coal Board charged with the task of reorganising and re-equipping the industry. The Board is required to pay its way on the average of good and bad years but has a government

advance of as much as £150 million spread over five years for capital expenditure in the sinking of new pits and installation of modern machinery.

The real crisis faced by the National Coal Board was primarily one of manpower. Before the First World War more than a million men were employed in the industry. In 1927 the figure was still 1,024,000, but after that there was a steady drop, accompanied by much unemployment and real poverty, to 756,000 in 1936.

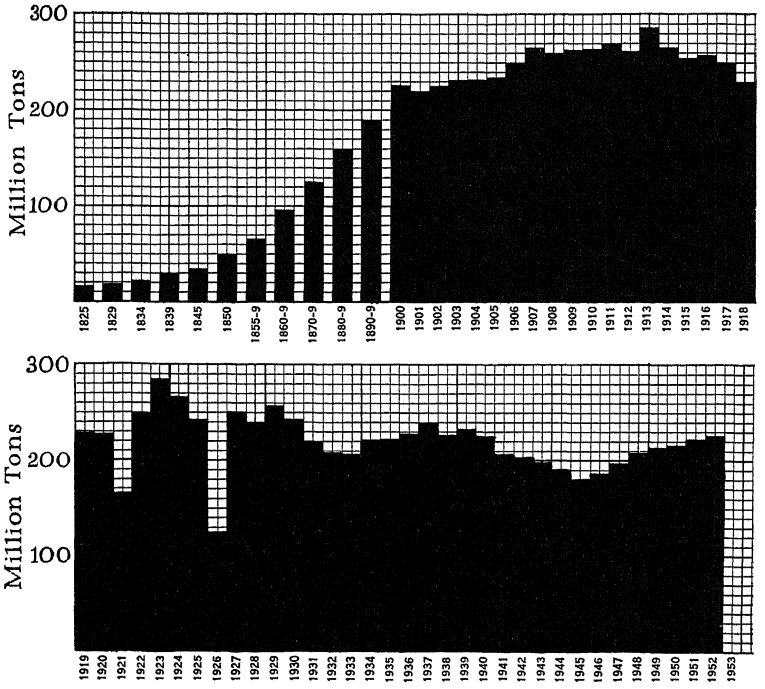


FIG. 139.—Graph showing the coal production of the British Isles

A slight rise followed, and then a renewed fall. During the Second World War about 700,000 were employed. The normal intake of young men almost ceased, and war-time production was maintained by older men, many of whom strained to the utmost for patriotic reasons at ages when they would normally have ceased work. As the war dragged on, the shortage of men became so acute that young men were directed to the mines instead of into the fighting forces, and these so-called "Bevin Boys" helped to maintain output.

After the war patriotic motives did not have the same force. Underground mining held few attractions for young men who had

lived an open-air life in the armed forces, and their fathers could not forget the years of unemployment between the wars and no longer encouraged their sons to take up their own old trade. In 1946 the low figure of 697,000 employed was reached, and of these only 626,000 were classed as "effectively" employed. Early in 1947 the National Coal Board introduced a five-day week to stimulate both production and recruitment, but production still lagged and recruitment failed to keep pace with wastage. Later in the year a substantial wage increase reintroduced the economic incentive, and several attempts were made to introduce Polish, Italian, and other foreign labour. The five-day week was found to lower output and later voluntary Saturday shifts were introduced. But the labour and output problems remained.

PROGRESS IN THE INDUSTRY

Contrary to ideas inculcated by political propaganda, the years between the wars saw marked progress in the coal industry in many directions. The Miner's Welfare Fund, set up with government backing in 1920 and established as a Commission in 1939, was empowered to levy a tax of one penny on every ton of coal raised. The money was used to improve the social conditions of the workers. In particular, the Commission built pit-head baths at the larger collieries. At first, so conservative are the older miners, there was bitter opposition to what was stigmatised as public washing in place of the tub in the kitchen at home, but this gradually changed to the extent that collieries without pit-head baths had difficulties in getting labour. Later the commission turned its attention to the provision of canteens serving hot meals.

The larger part of the coal production comes from deep, modern collieries, many of them almost completely electrified and employing a thousand men or more, frequently even 5,000. Coal-cutting machinery is now in extensive use except where seams are very thin and shattered. The proportion of machine-mined coal increased from 19 per cent. in 1924 to 42 per cent. in 1933 and 59 per cent. in 1938. In some fields where conditions are suitable the percentage is over 80; it was 81 in Northumberland in 1933. In 1938 not only was 59 per cent. of the total output cut by machines but 54 per cent. was mechanically conveyed. Mechanisation advanced rapidly during the war, so that in 1945 these figures were 72 and 71 per cent. respectively. Broadly speaking over four-fifths of British coal is now cut and conveyed mechanically. The Leicestershire field reported 97 per cent. of coal cut by machinery in 1944.

Unfortunately, mechanisation has not been markedly reflected in increased output per employee. This figure fell from 301·9 tons to 245·2 tons in 1945, and the output per man shift from 1·17 tons

in 1937 to 1·00 in 1945. There followed a small improvement. In 1950 the total output of 216,300,000 tons (including opencast) was obtained by 697,000 wage earners, who were recorded on colliery books, which is 310·3 tons per man. From the low figure of 1·00 ton per man-shift in 1945, there was a steady rise to 1·19 in 1950—the first year in which it overtook the 1937 figure. Wages rose from 10*s.* 7*d.* per ton of coal disposable commercially in 1938 to 25*s.* 5*d.* in 1945—nearly 150 per cent. By 1950 the figure had increased to 29*s.* 8*d*

THE DISPOSITION OF THE COALFIELDS

Unlike her neighbours on the Continent of Europe, Britain has practically no production nor resources of lignite or brown coal.

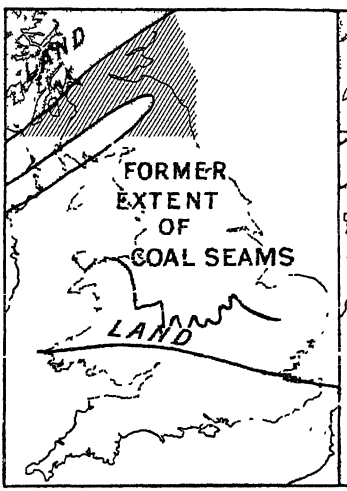


FIG. 140.—The geography of the Coal Measure period

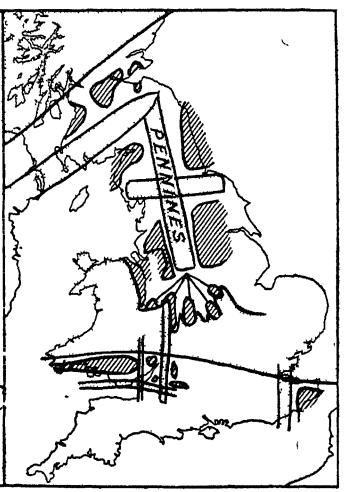


FIG. 141.—The effect of subsequent earth movements in separating the British Coal Measures into a number of basins

The small field containing such coals of Tertiary age at Bovey Tracy in Devonshire is essentially unimportant. Britain's coals are nearly all of Carboniferous age; those of England and Wales occurring in the Coal Measures (Upper Carboniferous), those of Scotland in both the Lower and Upper Carboniferous. There is an isolated mine at Brora on the coast of Sutherland in northern Scotland, which works coal of Jurassic age. Britain is perhaps unfortunate in that a former wide spread of Coal Measure rocks has been broken up into a number of separate small areas by subsequent earth movements and denudation; and an attempt to reconstruct

the geography of the period may assist in the understanding of the disposition of existing fields.

In Chapter II we have already outlined the conditions under which the Coal Measures of Britain were deposited.

In early Carboniferous time the present Highlands of Scotland formed part of a great continental mass. Along its southern fringe were deltaic flats, and on them flourished the extensive swamp forests from which coals of Lower Carboniferous age derive. These older coal seams die out southward except for a few in Northumberland. It was not until Upper Carboniferous time that conditions suitable for the growth of coal forests spread over the larger part of England and Wales. At that time, it is believed, a great deltaic flat stretched from the margin of the Scottish land mass to St. George's Land, a low land ridge crossing the Midlands of England. Along the southern fringe of St. George's Land conditions were also suitable for the growth of Coal Measure forests, but farther south (in Devon and Cornwall) rocks of the same age are barren. St. George's Land remained relatively stable during Coal Measure time, whereas the areas to the north and south underwent successive depressions. It would seem that there were thus originally two enormous coal fields of Upper Carboniferous or Coal Measure age, one reaching from the Highlands of Scotland to the Midlands of England, the other lying south of St. George's Land and extending from South Wales across southern England into Kent and on into northern France and Belgium. In the northern area, coal seams traced southward toward the old land bridge are found to get gradually closer together and, in some places, eventually to merge. This is the case with the famous Thick Coal—as much as 36 feet thick—of the South Staffordshire or Black Country coal field, and this explains why the coals in some of the Midland fields have been virtually worked out.

The Armorican or Hercynian earth movements at the end of the Carboniferous period flexed the British Coal Measures into a series of east–west and north–south folds. Where two downfolds cross, an oval basin may be formed, as in the little Forest of Dean coal field. Folding and subsequent denudation of the anticlines resulted in the separation of the British coal deposits into a series of basins. Each basin is geologically a distinct unit and may be said to constitute a coal field. Where the basin is completely surrounded by older rocks, the exact extent of the field is known, and total reserves can be closely calculated. The South Wales and Forest of Dean fields are good examples of such basins; the Scottish fields afford other examples. In other places the Coal Measures may plunge down or be faulted down to such depths that the existence of coal can only be assumed; in any case it is beyond workable depth. Thus between the North Wales and Lancashire fields coal probably underlies the whole Cheshire plain, but at depths certainly exceeding

4,000 feet. In still other places the Coal Measures plunge beneath rocks or the sea, and the precise limits of the field remain unknown. This is the case with the great Yorkshire and Durham fields.

Unfortunately, different parts of a single geological coal field may be given separate names, and in recent years nomenclature has been further confused by the adoption of regions with new names.[1]

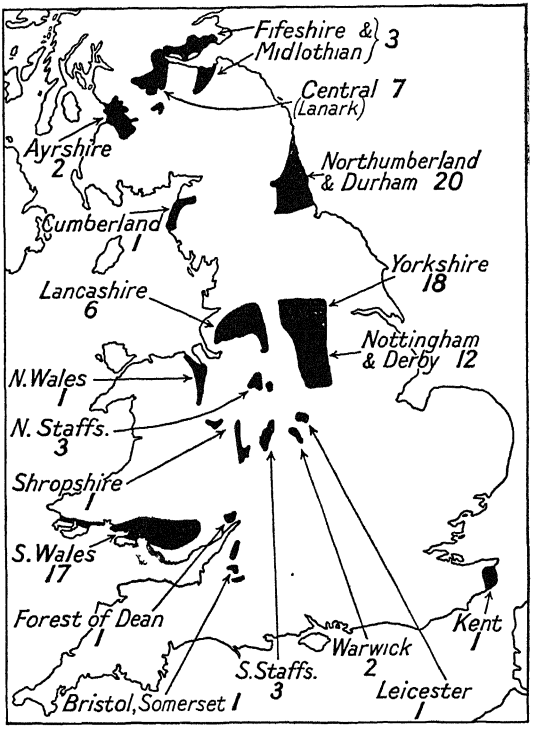


FIG. 142.—The Coalfields of Britain and their average output expressed as a percentage of the total output

The extent of the fields as known at present is shown on the official map of Coal and Iron on the scale of 1:625,000 prepared by the Maps Research Office of the Ministry of Town and Country Planning and published by the Ordnance Survey.

BRITISH COAL RESERVES

No calculations have been made recently of Britain's total coal reserves. The figures commonly used are those given in the Table. When the Coal Act, 1938, became law, the ownership of all unworked

[1] Particularly stupid and confusing is the use by the Ministry of Fuel and Power of the term "North-Eastern Field" meaning in fact West and South Yorkshire.

ESTIMATES OF TOTAL BRITISH RESERVES OF COAL

In millions of tons (rounded) in seams of 1 foot and more in thickness to a depth of 4,000 feet[1]

	Royal Commission		Strahan	Jevons	P E P
	1871[2]	1905[3]	1913[4]	1915[5]	1945[8]
Proved fields	90,000	101,000	133,000[6]	136,000[6]	40,000
Unproved fields	56,000	40,000	46,000[7]	61,000[7]	
Total	146,000	141,000	179,000	197,000	
Mined since date given	15,000	9,000	7,000	7,000	
Remaining in 1945	131,000	134,000	172,000	190,000	40,000

[1] The Royal Commission of 1905 estimated that 79·3 per cent. of the available reserves were in seams of two feet and more in thickness.

[2] Report of the Commission Appointed to Enquire into the Several Matters Relating to Coal in the United Kingdom, 3 vols., London, 1871.

[3] Final Report of the Royal Commission on Coal Supplies, Part 1, General Report, London, 1905.

[4] A. Strahan: "The Coal Resources of Great Britain," *in The Coal Resources of the World* (3 vols and atlas), 12th International Geological Congress, Canada, 1913, Vol. 2, Toronto, 1913, pp. 597–628, reference on p. 625.

[5] H. S. Jevons: *The British Coal Trade*. London, 1915 (2nd. edit, 1920), p. 739.

[6] "Actual reserves."

[7] "Probable and possible reserves."

[8] Known workable reserves in seams 18 inches and more in thickness exclusive of reserves not economical to work at present, as calculated by P E P, "The British Fuel and Power Industries," 1947, from the official Regional Survey Reports of the Ministry of Fuel and Power.

coal passed from private hands to the nation. Previously, ownership of land had normally included mineral rights, and it is broadly true that the great fortunes made in the industry were those derived from royalties, often accruing to owners who had no active interest in the industry, rather than from profits of exploitation. These owners were compensated by an amount equivalent to the estimated capital value of the coal (as of July 1, 1942) that could reasonably be expected to be raised from the holding in the hundred years 1942–2042.

Thus details were collected of "developed reserves" or total planned output for 1942–2042. The total is 20,500,400,000 tons, classified for the first time according to type (p. 287). The Coal Survey officers only incidentally recorded known reserves not scheduled to be worked in the next hundred years, but the additional total was 15 billion long tons. They ignored seams less than 2 feet thick and reserves below 4,000 feet (4,500 feet in some collieries in Lancashire and northern Staffordshire). During the Second World War numerous borings made in the search for oil revealed previously unknown extensions of existing coal fields as well as new areas with possibilities for exploitation. Modern developments in deep mining

prove that there is no need to regard 4,000 feet as a lower limit. On the most conservative estimates Britain has definitely enough coal, proved and capable of being mined economically by existing methods, to last her at the present rate of consumption for at least two hundred years. Indeed, there seems every reason to accept the older estimates that there is probably enough for 750 years, even if we take the old rate of 250 million tons a year rather than the 1947 target of 200 million. Among European countries only Germany (pre-1939 frontiers) is so well served. It must be noted that reserves are not shared equally; in some fields exhaustion is in sight.

THE CLASSIFICATION OF BRITISH COALS

British coals include anthracite in the western part of the South Wales field, the remainder are bituminous or humic coals. It has long been the custom to use a rough classification into types based on the suitability of the coals for different purposes. Thus steam coals are hard, burn with little flame and little soot and therefore much valued for bunker purposes and for ships. Similar types are appreciated for some domestic purposes under the name of "Kitchen Nuts" when broken to a small size, and are suitable for consumption in enclosed stoves. By way of contrast, household coals, those which are favoured for burning in open grates, still so prevalent in English homes, are coals which give a pleasant flame, and are described by the housewife as being "gassy." Then the coking property of coals is important. Good coking coals should also, of course, yield a large supply of gas, and if the coke is required for the iron industry, it is essential that it should be a good hard coke, and should not crush when loaded with a considerable weight of iron ore above it. The relative absence of intense folding in the British Isles has resulted in the comparatively small proportion of powdered coals of the types extensively used on the Continent of Europe for the manufacture of briquettes. It is indeed only in recent years that coal slack—dust—has been utilised at all in this country, and only a few collieries have briquetting plant for this purpose. The coal dust requires to be mixed with some material, such as pitch, as a binding substance.

In recent years a more exact classification has been brought into use. This scheme was evolved by the Coal Survey officers to assist the Ministry of Fuel and Power in making a census of fuel consumption. The arbitrary "code-numbers" are based on content of volatile matter (on the dry ash-free basis) and coking properties.

I Low-volatile coals (volatile matter 20 per cent. or less)

100 Anthracite: non-caking, volatile matter less than 10 per cent.

200 Low-volatile steam coals (types distinguished as 201, 202, 203, 204, 206).

II Medium-volatile coals (volatile matter 20·1–30·0 per cent.)
300 Scottish medium-volatile, non-caking or weakly caking
301 Coking coals, strongly caking. (These are the metallurgical coking coals of Durham and South Wales.)

III High-volatile coals (volatile matter over 30·0 per cent.). (Each group is divided into 01 and 02, with respectively less and more than 37·0 per cent. of volatile matter.)
400 Very strongly caking coals
500 Strongly caking coals
600 Medium caking coals
700 Weakly caking coals
800 Very weakly caking coals
900 Non-caking coals.

All coals have a certain proportion of ash and a high proportion is noticeable in some coal now being mined. It has been authoritatively stated that 2½ per cent. should be deducted from 1950 production to allow for the poorer coals compared with pre-1939 output.

SUMMARY OF DEVELOPABLE COAL RESERVES IN GREAT BRITAIN[1]

In millions of tons

Type of Coal	Planned Output 1942–2042		Proved Additional Reserves		Output 1938	
	Tons	%	Tons	%	Tons	%
Anthracite (100) . .	704·6	3·4	914·3	6·8	6 1	2 7
Steam coals (200, 300; low and medium volatile) .	1,861·9	9 1	1,306·6	9·8	20 7	9·1
Coking coals (301, 401; medium volatile)	1,556·2	7·6	1,130·5	8·5	20·7	9·1
Coking-gas and gas coals (400, 500, 600; high volatile)	7,402·3	36·1	3,953 5	29·5	84·0	36 8
Household and industrial coals (700; high volatile weakly caking) . . .	2,894·4	14·1	1,448·0	10 8	34·2	15·0
Household and general coals (800, 900; high volatile non-caking) . .	5,634·1	27 5	4,623·8	34 6	60 7	26 6
Unclassified . . .	446 9	2·2	—	—	1·8	0 7
	20,500·4	100 0	13,376·7[2]	100·0	228·2	100 0

[1] Data from "Rapid Survey of Coal Reserves and Production," Fuel Research Board, Dept. of Scientific and Industrial Research, 1946.
[2] Exclusive of at least 2,000 million tons unclassified.

RESERVE TYPES OF THE FIELDS

The life of the collieries of Northumberland and Durham, as based on reserves and planned outputs, shows a general increase toward the east, so that it is longest—certainly well over a century—in the coastal areas and under the North Sea. West Durham is a dying field, with many abandoned mines and an estimated life of less than 10 years; it is a problem area. The government has constituted the whole coal field a "Development Area"—an area in which the government will encourage industrial development and where the appropriate department of the Board of Trade will invite new industry to settle. In the east the new town of Peterlee is being built—but this does not solve the problem whether the old, western part of the field should be allowed to die or whether an attempt should be made to change its economic basis. The change in the physical and chemical characters of any one seam when it is traced entirely across the field is greater than the differences between the various seams in a given locality in the field. The famous medium-volatile coking coals of West Durham (301) pass eastward into coking-gas and gas coals (401, 501, 502) and northward into medium and weakly caking coals (602, 702) marketed chiefly for power stations, general industrial use, and house coal; they are of excellent quality.

The Cumberland coals are all of types 501 and 502, and large reserves, difficult to prove, are believed to exist under the sea and at great depths northward.

In the West Yorkshire field types 500 and 600 predominate. More than 70 per cent. of the production has come from five seams, but there is a noticeable move eastward to the deeper part of the field, and seams with other types of coal are likely to be worked. In South Yorkshire, the Sheffield area, the dominant types are 500, 600, and 700; farther south, in Nottinghamshire, they are 800; and the progressive change continues into the fields of Leicestershire and South Derbyshire, where the coals are mainly non-caking (900), especially in seams of more than five feet thick. In the other Midland fields very weakly caking and non-caking coals (800–900) predominate.

For the Lancashire field (mainly types 600–700) and North Staffordshire (400–800) the future is less clearly foreseeable, because of the extensive faulting and steep dips, but there are undoubtedly very great reserves at depth. In the small Forest of Dean field exhaustion of the chief seam is almost certain to lead to a drop in production.

South Wales coals range from 100 to 400; anthracite predominating in the north-west, dry steam coals (200) in the heart of the field, and medium- or high-volatile coals toward the south-east. In the

entirely hidden East Kent field the chief reserves are also of type 200.

Scotland has coals of very varied types. Though anthracite is absent, there are excellent steam coals and a wide range of high-volatile coals.

OPENCAST WORKING AND DRIFT MINING

It may seem strange that during the Second World War, after more than a century of essentially deep mining, Britain returned to the quarrying or opencast working of coal to such an extent that from 1944 onwards nearly 10 per cent. of the production was obtained in this way—as much as 12·2 per cent. in 1950. But the reasons are not far to seek. In many of the fields the land surface lies in long dip slopes, paralleling over considerable areas the dip of the underlying Coal Measures, and in steep scarp slopes. The coal seam naturally follows the dip slope but may lie from a dozen to a hundred feet or more below the surface. In the past it was too deep to quarry, too shallow to mine without constant subsidence damage.

Large-scale mechanical excavators, dragline scrapers, and bull-dozers now make it possible to remove greater thicknesses of overburden, and to do it economically. The lowest working costs result when the overburden is left piled in huge ridges, but the resulting "hill and dale" becomes virtually a desert of no economic value. Where, as in parts of South Wales, wild moorland at heights of a thousand feet and more above sea level is involved, the loss is not serious, but it is a very different matter in the rich farmland of Leicestershire and Yorkshire, where every acre is precious. There it is necessary to restore the land for agricultural or other uses, and in some places this has been done so effectively that only one season's crops have been lost. Hotly disputed questions remain: Is it, for example, essential, or at least desirable, to scrape off the topsoil and later to spread it over the restored surface, or are the results incommensurate with the heavy cost? Is working justified over famous parks, gardens, and beauty spots, some of them perhaps now the possession of the nation?

Much of the high cost of opencast coal working in the war years may be attributed to its experimental nature, and on the whole costs now compare reasonably with those of deep mining. It was feared that the coal might be weathered and consequently poor, but this fear has been shown in many instances to be groundless. Opencast mining eases the labour position, since skilled miners are not needed and many semi-skilled workers are content with a surface job who would not go underground. However, although temporarily important, open-cast working is not likely to continue for long

to make a significant contribution to Britain's output. Drift mining has also been revived and has been encouraged by the fact that such local enterprises have not been nationalised, though working is by licence from the National Coal Board.

DEEP MINING

The early coal mines were doubtless open quarries along the exposed edges of the seams. Then the seams were followed under the ground by adit mines, especially in those areas where it was possible to drain the shallow mines by a simple drain running out on to a neighbouring valley side. Working by bell-pits (see below, p. 314) was later carried out in many places. Mining by means of shafts followed, but for a long time the depth of the mines was severely limited by the impossibility of effectively draining the workings. The invention of Newcomen's Atmospheric Pumping Engine, which passed into general use in the Northumberland-Durham field about 1750, did much to remove this difficulty. Later the invention of the Davy Safety Lamp again rendered possible mining to greater depths, where previously the accumulation of fire-damp had been a great source of danger.

Two principal systems of mining have been followed in this country—the "pillar and stall" method, by which a pillar of unworked coal is left to support the roof and only the intervening part of the coal taken out—and the "longwall" method, by which the whole of the coal is removed, the roof being temporarily supported by pit props, and then allowed gradually to collapse as the coal is worked out. The first method sounds, and is actually, very wasteful, but it is sometimes economical because of the saving in timbering which is otherwise required. The importation of pit props into the country gives rise to a trade of very considerable importance. For example, in the year 1931, pit props to the total of 2,000,000 loads or tons valued at £3,000,000 were imported. During the nineteenth century, with the enormous development of British manufacturing industries, the expansion of the railways and their consequent consumption of coal, and also the facilities which they provided for removing it, the output of coal increased by leaps and bounds, from about 10 or 15 million tons in 1800 to 220 million in 1900. Collieries became dotted all over the exposed Coal Measures, especially where the coal was near the surface. Workings were not always well planned. In many cases no record was kept of the coal which was removed, and no plans are available of old workings. It is by no means an uncommon occurrence for a mine operating at the present day to break suddenly into an old working, with a consequent danger of flooding from the water which has

accumulated in the old workings. As time went on, underground workings were extended to cover the same area as the land holdings on the surface, since the colliery companies held rights from the surface landlords. This led to very irregular and curiously shaped underground concessions and was one of the reasons for the nationalisation of coal—it is now possible to plan an economic layout of workings independently of surface ownership.

THE PRINCIPAL FIELDS

The following table indicates the relative importance of Britain's coalfields.

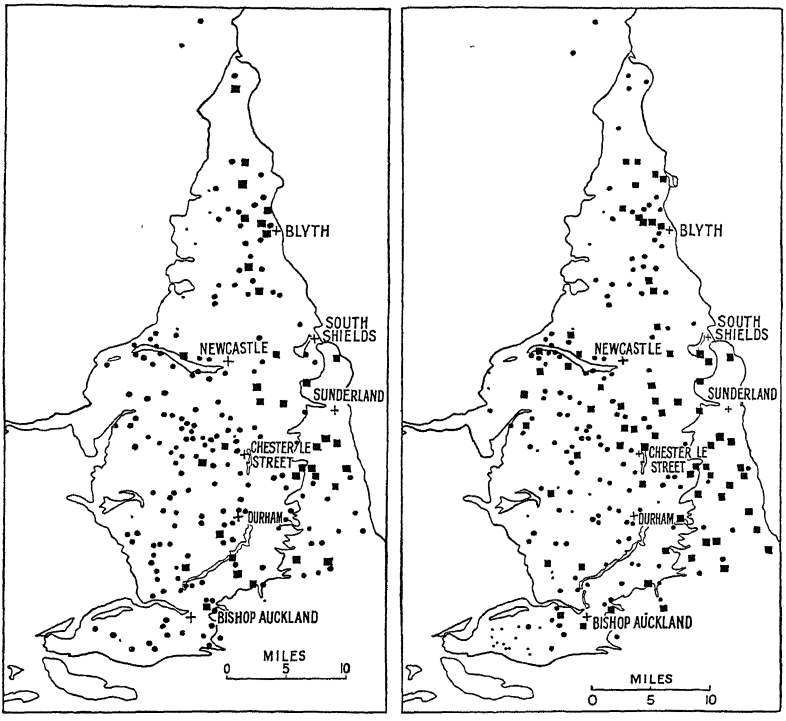
Minimum proved reserves	Field	Yearly average output in million tons				
		1909–13	1922–4	1927–9	1931–5	1950
1,537	Ayrshire	4 1	4·5	4·3	3·9	3 5
3,049	Lanarkshire	17·4	19 4	16·6	13·6	8·5
2,500	Midlothian	6 1	4 4	4·7	4 7	3·9
3,742	Fifeshire	8·8	8·5	8 1	7 8	7·3
5,510	Northumberland	14·0	13 7	13 7	13 0	12·1
870	Durham	40 4	36·6	36·1	29·3	26·5
1,528	Cumberland	2·2	2·2	2·2	1·5	1·1
26,000	Yorkshire	39·0	64·7	45·2	39 3	32·6
	Notts and Derby	31 5	30·2	28 5	26 6	36·3
4,367	North Staffordshire	13 9	6·3	5·9	5·9	11·0 †
1,415	South Staffordshire		1·5	6·7	6·2	0·9
1,825	Leicestershire	—*	3 1	2·5	2·4	3·8
1,127	Warwickshire	—*	5 1	4·7	5·0	5·1
4,239	Lancashire	27 3	19·2	15 9	13·7	12·5
1,736	North Wales		3·2	3·4	2·8	2·2
26,000	South Wales	51 2	52·3	45 9	35·3	23 0
259	Forest of Dean	—*	1·3	1·3	1·2	0·8
4,198	Bristol and Somerset	2·7	1·3	1·0	0 9	0·5
2,000	East Kent	—*	0 4	0·9	1·9	1·7

* Details not available † Includes Cannock

Northumberland and Durham

The Coal Measures in Northumberland and Durham dip away from the Pennine upland, and eventually pass under the waters of the North Sea. In eastern Durham they are first covered by a thickness of Magnesian Limestone and other Permian sediments. The older shallower workings of the field are thus situated on the flanks of the Pennines in the west, the larger and deeper modern collieries are nearly all to the east, and in many cases the coal is worked under a considerable thickness of overlying rock. Along the Northumbrian coast the coal is followed under the sea, and four miles from the coast may be taken as the economic limit for the

working of the coalfield. The three maps (Figs. 143, 144, 145) show the position and size of the collieries in 1900 compared with those in 1931 and 1950 and demonstrate very clearly how the principal mines of the district have moved eastwards in the last thirty years. In 1900 it will be noticed that there were only eleven large collieries (*i.e.* employing more than 1,000 men) in the eastern, hidden part of the field; whereas by 1950, the number had increased to 23.



FIGS. 143 and 144.—The Northumberland and Durham Coalfield in 1900 and 1931

The square dots represent collieries employing more than 1,000 men; the large round dots, collieries employing between 100 and 1,000 men, the small dots collieries employing less than 100. The thin black line shows the limits of the *exposed* coalfield. It should be noted that in 1900 there were only 11 large collieries in the hidden coalfield; in 1931 the number had increased to 20

Some notes are given below on the development of coal mining in the Northumberland and Durham field; they indicate that coal working began at a very early date, and that it has always been associated with the movement of coal by water, either to other parts of this country, or to foreign countries. The field is, indeed, more conveniently situated for the export of coal by sea than any other large *English* field. Hence it is not surprising that in the inter-war years 35 per cent. of all the coal mined was exported. A large

part of all the coal mined is taken to other parts of Britain by water, as for example to London. At all the coast ports, such as Blyth, as well as along the Tyne itself, are the erections known as staithes. The coal wagons are run straight on to these, and the coal is pitched into the holds of colliers waiting below. Because of its former dependence upon the export industry, the Northumberland–Durham coalfield felt the effects of the post-1920 depression more than other fields in the country. In this respect its fortunes compared with those of South Wales. The maps of this field add point to the general remarks given above. One notices, for example, the position of Bishop Auckland, a town of considerable size in the south-west of the field in an area which has for long been famous for the very excellent quality of its coking coal—perhaps the best of all coking coals for the iron-smelting industry. Yet Bishop Auckland is in a part of the field which must of necessity become worked out at an early date. It seems difficult to hope for the resuscitation of prosperity in such an area merely because of its actual geographical position on the field.

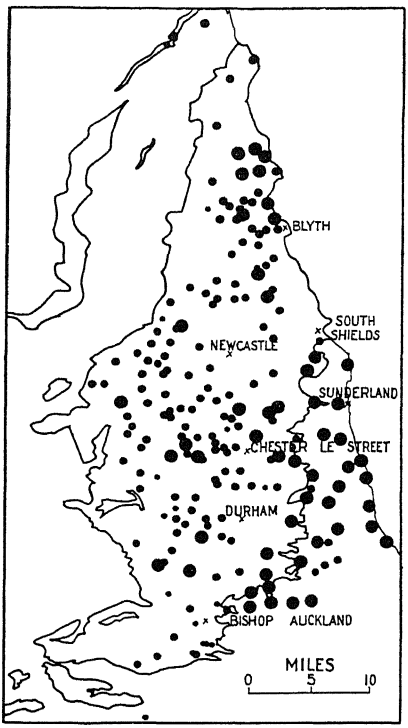


FIG. 145.—The Northumberland and Durham Coalfield, 1950

The series of coalfield maps for 1950 were prepared especially for this work under the direction of Dr. E. C. Willatts. The symbols are the same as for the 1931 maps except that square dots have been replaced by round ones

The Lower Coal Measures, that is those exposed in the extreme

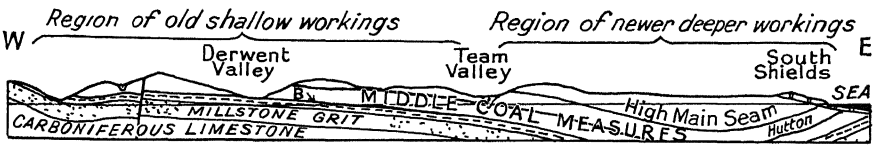


FIG. 146.—Section across the northern part of the Durham field (just south of the Tyne), showing the valleys which facilitated the early working of coal. B=Brockwell Seam (after Walcot Gibson)

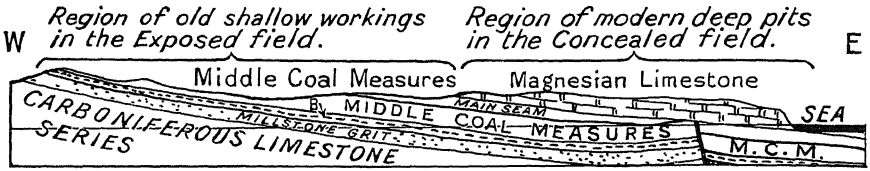


FIG. 147.—Section across the southern part of the Durham field, showing the thick mass of Magnesian Limestone covering the concealed coalfield. B = Brockwell Seam (after Walcot Gibson)

western part of the field, contain a few thin but workable coals. The productive measures of the field begin with the Brockwell or Denton Low Main coal, and contain altogether about twenty-three workable coals. Many of the seams rest on beds of valuable fireclay, extensively used for the manufacture of firebricks. Amongst the best known coals are the Hutton and Low Main; the latter is a good gas and house coal in Durham, but north of the Tyne becomes a steam coal. Higher up is the famous High Main of South Northumberland, known also as the Wallsend coal, for household purposes; it was from six to seven feet thick, but is now very largely exhausted. Although the coals of Durham include some of the best coking and gas coals in the kingdom, others are much more suitable for household coal. There appears to be little difference in the chemical characters, the difference in the commercial value and use apparently depending more upon physical and textural features. Steam coals become prevalent north of the Tyne. Two sections given here show the general

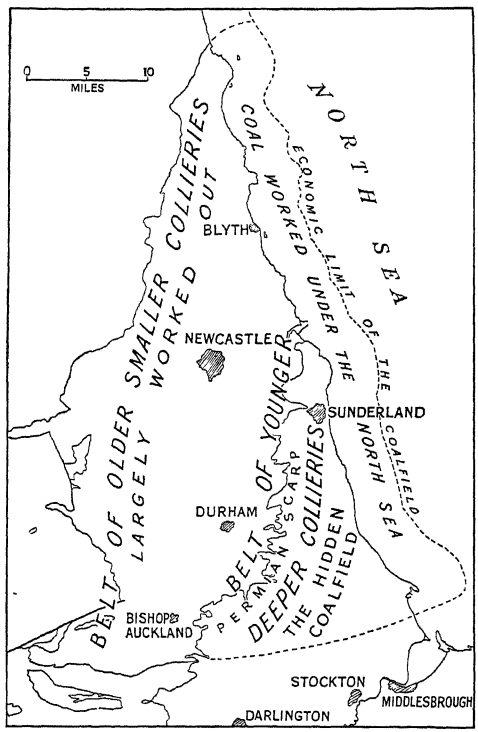


FIG. 148.—Map showing the limits of the Northumberland and Durham Coalfield

disposition of the coal seams, and the way in which the Coal Measures are slightly folded under the cover of Magnesian Limestone. Numerous faults and igneous dykes cross the field, usually in an east and west direction. Two of the best-known faults are the Butter Knowle in South Durham with a throw of between 240 and 420 feet, whilst the famous Ninety Fathoms Fault shifts the Coal Measures in places no less than 1,000 feet. To the north and west of the Coal Measures, the Carboniferous Limestone series occurs and, as in Scotland, this contains in Northumberland some workable coals. Hence a few collieries are situated outside the area marked as Coal Measures on the geological map, notably near Hexham and south of Berwick.

The gradual development of the Northumberland and Durham coalfield influenced the initiation and progress of manufacturing industries, not only there but throughout this country. Coal began to be used as a domestic fuel as early as the fourteenth century, and medieval London received its supplies by water as it does to a large extent to-day. It is not known whether the term "sea coal" refers to the fact that it was sea-borne from the northern coalfield, or whether it refers to the fact that fragments of coal were gathered there on the seashore, having been washed out of seams cropping out on the cliffs or along the coast itself. But, in any case, the scene of its early exploitation was the Northumberland and Durham coalfield, a field peculiarly suited for the primitive working of the mineral. Not only did the seams occur near the coast or near navigable water along the Tyne and the Wear, but the seams out-cropping at the surface could be worked by simple outcrop mining and then followed underground by gently sloping tunnels or adits. Even so, the early miner would soon have been prevented from following the seam underground owing to difficulties of drainage had it not been for the relief of the area. Over much of the tract, especially in the west of the field where the seams actually outcrop, the land is 200 or even 300 feet above sea level. The surface is broken up by considerable valleys, the lower course of the Tyne itself occupies a valley which, from its steeply sloping and quite lofty sides, is almost worthy to be described as a gorge. Thus the early miner had no particular difficulty in draining his adit mines to the lower ground of the valleys. Further, haulage presented comparatively few difficulties, and it is noteworthy that even as late as the beginning of the nineteenth century, only a hundred and fifty years ago, all the collieries were readily accessible from navigable water. In the very early days the coal was taken down in baskets by trains of pack horses to the nearest point on the Tyne or on the Wear, which was navigable by the "keels" or coal barges. Lower down the river the coal was transferred from the keels to the 100-ton wooden coal vessels by which the coal was taken to London or elsewhere. More than 300 years ago there were 400 vessels of this type engaged in shipping coal from the Tyne alone. Much of the surface of Northumberland and Durham is covered with a heavy glacial drift. The paths and primitive roads were easily churned into a thick sticky mud by the trains of pack horses, and the condition of these tracks made their use by wheeled wagons practically impossible. The laying down of rough wooden tracks (corduroy roads) improved matters, and it was an obvious step to lay on these wooden rails which guided the wheels of the wagons then used. The next stage was the use of cast-iron rails and, later, flanged wheels. In many cases, even over considerable distances the loaded coal trucks

descended by gravity and pulled up at the same time the empty trucks. In other cases the wagons were horse drawn. The railroad had evolved itself: it merely awaited the coming of the steam engine. The opening of the Stockton and Darlington Railway in 1825 solved what had previously been a very serious problem, and that was the transport of coal from the coalfield to the Tees.[1] Previously it had actually been shipped from Tyneside to the Tees, and this illustrates the reason for the comparatively late development of the southern part of the Durham coalfield

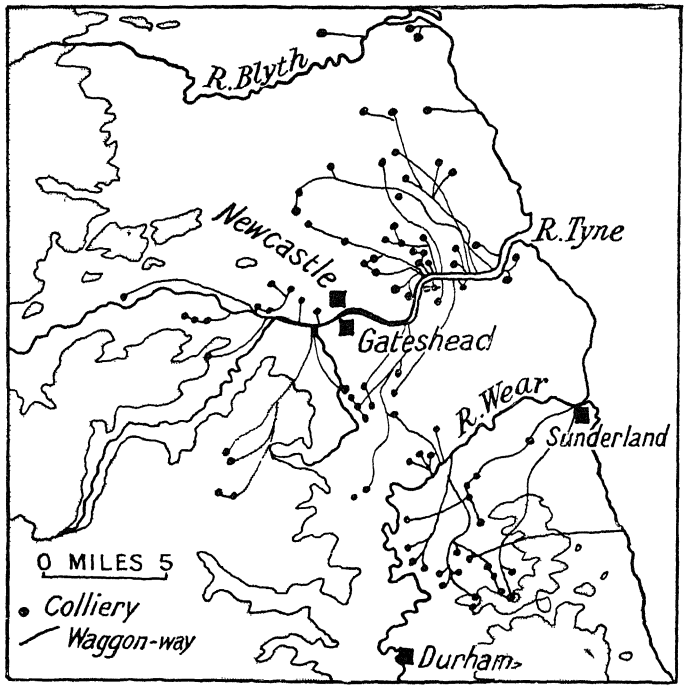


FIG. 149.—Old wagon ways and collieries, Northumberland and Durham field, 1830, showing the importance of access from navigable water (after Rodwell Jones). Land over 400 feet, stippled

as well as pointing to the great difficulties of inland transport just over a hundred years ago. Within a few years the railway was extended to Middlesbrough and to Hartlepool. Reference has already been made to the steep-sided valley of the Tyne, and although there is a stretch of low-lying level land flanking the watercourse itself, advantage was taken at an early stage of the high banks by building out wooden projections from them in such a way that the coal wagons could be run out to the end—hence the origin of the staithes mentioned above.

Cumberland

Though only a small field, the Cumberland field resembles that on the other side of the Pennines by the way in which the Coal

[1] C. E. Lee, *The Evolution of Railways*, London, 1937. C. F. Dendy Marshall, *A History of British Railways down to the year* 1830, Oxford, 1938.

Measures run under the sea, but this time westwards under the waters of the Irish Sea. The larger collieries are all situated on or near the coast, and the workings extend for a considerable distance—up to the limit of about four miles—under the sea, the limit being determined approximately by the cost of haulage from the working face to the shaft, which of necessity must remain on land. In addition to the exposed area and the area under the sea, there is a small extension of the coalfield under younger rocks towards the south, but a much larger extension to the north of Aspatria, where the Coal Measures are covered by Triassic rocks. It is probable that the Coal Measures extend right underneath the lowlands of the Solway

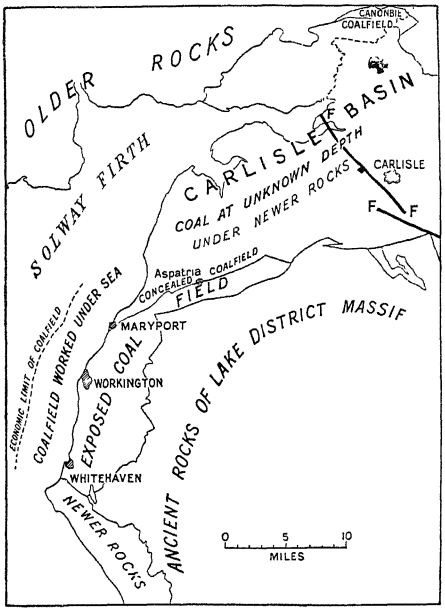


FIG. 150.—Map showing the limits of the Cumberland Coalfield

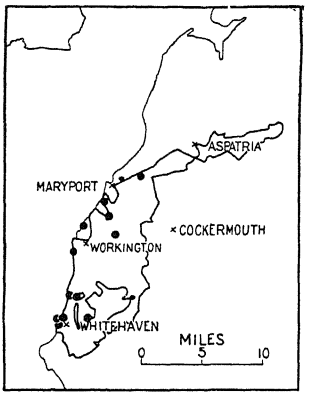


FIG. 151.—Collieries of the Cumberland Coalfield, 1950
(For explanation, see Fig 145)

marshes or the Carlisle Basin and reappear as the tiny Canonbie coalfield situated some distance to the north of Carlisle. The Coal Measures dip away from the uplift of the Lake District, that is towards the west and north-west. There are numerous faults with throws of from 300 to 600 feet running from north-west to south-east across the coalfield, and the northern edge of the worked field in Cumberland is determined by a complicated belt of fracture. It is not known to what depth the Coal Measures are faulted down to the north of that line, and whether they will ever be worked under the Solway lowlands or not. In the Whitehaven area the Main Band (five to six feet thick) is the most valuable seam.

Lancashire and Cheshire

On a geological map, the Lancashire coalfield appears as a triangular patch of exposed Coal Measures lying to the west of the Millstone Grit and older rocks of the Pennines. In the heart of the exposed Coal Measures there are considerable areas of Millstone Grit brought up by the Rossendale anticline. Overlying the Millstone Grits are the Lower Coal Measures—between 1,400 and 2,000 feet thick—and the only Coal Measures present over a large part of the field belong to this period. But the Lower Coal Measures are poor in coals, and most of the productive and thicker seams now being worked are in the Middle Coal Measures. Hence

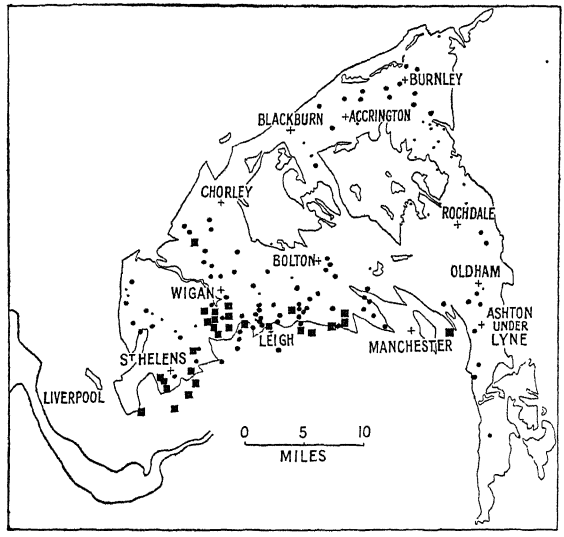


FIG. 152.—The Lancashire Coalfield, 1931

it is found that large and important collieries are restricted to certain portions only of the exposed Coal Measures; and one may say that the Lancashire coalfield really falls into three parts:

(1) *The Burnley Coalfield.*—This is a small basin of Middle Coal Measures lying at the northern apex of the field and separated from south Lancashire by the Millstone Grit anticline. All the thicker coals are exhausted, and though such coals as the Arley, Dandy, and King are still worked, this northern part of the Lancashire field is not now very important.

(2) *The South Lancashire Coalfield.*—In the south the rocks dip comparatively steeply away from the Millstone Grit and the Lower Coal Measures towards the south, where they pass underneath a cover of Triassic rocks. Here is to be found probably the maximum thickness reached by Coal Measure rocks in the British Isles, but

unfortunately the southward dip of the rocks increases as they pass under the Triassic cover, and thus the hidden coalfield has economically a limited extent towards the south. It is probable that Coal Measures underlie the whole of the Triassic Plain of Cheshire, and are connected directly with the fields of North Wales and North Staffordshire. Whether these deep-seated Coal Measures under the Triassic Plain of Cheshire will ever be worked is not yet known. The curiously irregular southern edge of the exposed measures in south Lancashire is due to the numerous and large faults which cut across the Coal Measures in a direction roughly from north-west to

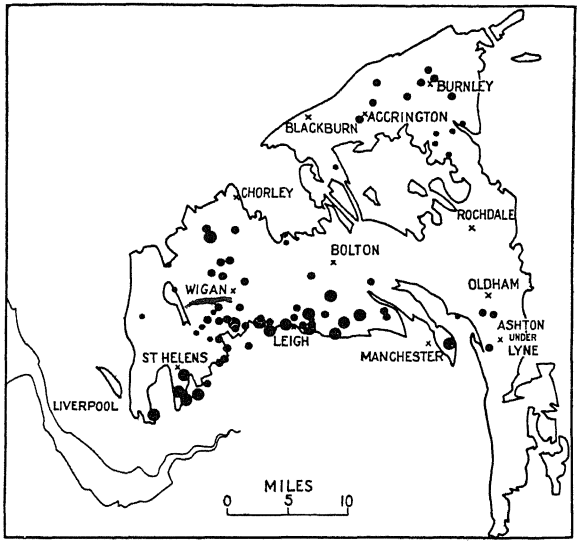


FIG. 153.—The Lancashire Coalfield, 1950

For explanation of signs, see Figs. 144, 145. The disposition of the collieries shows clearly the separation into the Burnley, South Lancashire, and Manchester fields, and the reason for regarding Wigan as the centre of the Lancashire coal-mining industry

south-east. Farther east, in the Manchester Field, the faults take on a north and south trend. That of the Irwell Valley has a throw estimated at 3,000 feet in places and 1,200 feet at Manchester. Farther east still the Bradford fault has a vertical displacement of something like 1,800 feet, so that the dislocation caused by these faults in the southern part of the coalfield is very serious indeed. As in so many of our coalfields, the greater part of the faulting took place before the deposition of the succeeding rocks of the Permian Period, and represents fracturing which was occasioned by the Armorican earth movements (see p. 15). Amongst the famous and important seams of this field, which have been extensively worked, are the Wigan 9-feet, the Arley, and Yard coals. In the Wigan district the well-known Wigan cannel coal (a corruption of "candle"

coal because splinters when lit by a match will burn with a flame like a candle) overlies the King coal. But this curious coal, which occurs practically nowhere else in Britain, is now practically exhausted. Its character is believed to be due to a difference in the mother substance of the coal, since it has been found to consist mainly of the spores or the seed-bearing organs of the ancient tree ferns which have gone to make up ordinary coals.

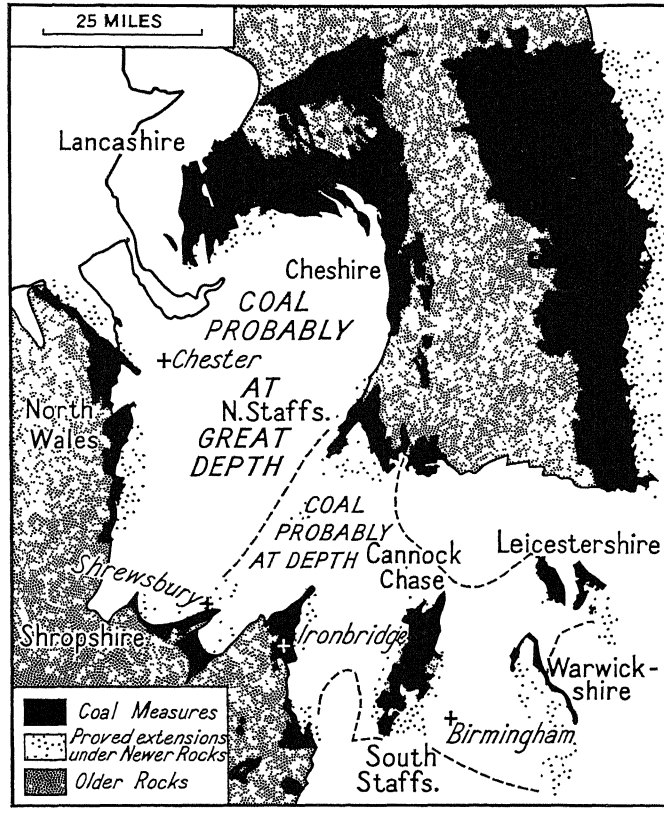


FIG. 154.—The exposed and hidden coalfields of the Midlands, and their relationship to one another

(3) *The Manchester Coalfield.*—This field is farther east, and the Coal Measures extend southwards into east Cheshire. Not unexpectedly the Coal Measures in this area can be correlated with those of north Staffordshire to the south, while it is possible to recognise some of the seams of the Yorkshire coalfield on the far side of the Pennines, and there is little doubt that the Coal Measures were originally deposited continuously across the area now occupied by the Pennine Uplift.

In the great triangular centre of the Lancashire coalfield, which is occupied by the Millstone Grit and the Lower Coal Measures, the country is mainly hilly, whereas the land occupied by the higher Coal Measures is for the most part comparatively low lying. Thus the few coals which have been worked in the Lower Coal Measures are often called "Mountain-Mine" coals because of their position.

The North Staffordshire or Potteries Coalfield

At its southern end, the western margin of the Pennine Uplift is marked by the existence of a number of small sharp folds. In the western, and by far the deepest fold, the Coal Measure sequence is preserved intact. In the Cheadle basin very much less remains, whilst farther north only the lowest and least productive parts of the Coal Measures have escaped denudation in the shallow troughs lying amongst the old rocks. Thus the North Staffordshire Coalfield is characterised by extensive folding and faulting of the Coal Measures. The most important coals occur in the Middle Coal Measures. There are some coals in the Lower Coal Measures, but in the Upper Coal Measures, apart from the lower group (Blackband Group), the rocks become reddish and barren, and are held by some to indicate the oncoming of desert conditions towards the close of the Coal Measure period in the British Isles. It is estimated that, in 4,000 feet of strata, the coalfield contains an aggregate of 140 feet of coal in thirty seams of over two feet in thickness, vertically distributed in such a manner as to permit most of them being worked by one pit at any one place. The coalfield is especially important because numerous seams of good quality are well adapted to the requirements of the industries which have become situated on the field. In the west there are some good gas and coking coals (400 to 800 types). These are now largely worked out but coking coals are being obtained from deeper seams in the centre of the syncline whilst reserves as yet unworked exist in the concealed southern extension of the field. Fireclays are important economically in this field, but the formerly valuable ironstones are practically exhausted. To the geologist, the North Staffordshire coalfield is one of the most interesting in the country because of the very complete succession of Coal Measure rocks which it exhibits, and because too of the interesting fossils, particularly those associated with marine bands which occur at several horizons in the sequence.

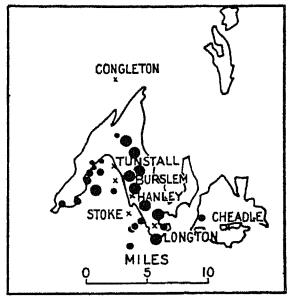


FIG. 155.—The North Staffordshire or Potteries Coalfield, 1950

The North Wales Coalfield

This coalfield may be taken next, because it represents the western exposed portion of the huge basin which probably underlies Cheshire.

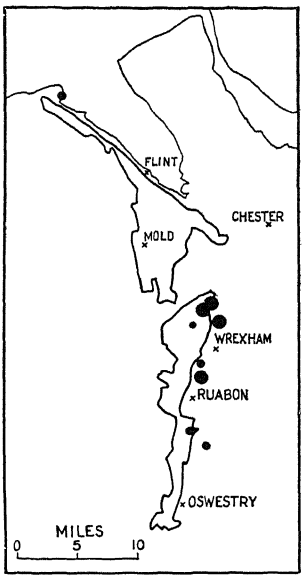


FIG. 156.—The North Wales Coalfield, 1950

The Carboniferous rocks rest unconformably on highly folded ancient sediments of the Ordovician and Silurian periods, indicating that the Welsh massif formed an island at the time of the deposition of the Coal Measure rocks. So much of the Coal Measures is covered by drift that the structure is only known from the results of mining, and a huge fracture running roughly from east to west divides the field approximately into a northern or Flintshire portion, and southern or Denbighshire portion. Some of the most important coals are steam coals (200 types), but in addition there are house and gas coals. Beneath the Triassic cover to the east, the coalfield has been worked in the southern part of the Wirral peninsula, and borings show that the whole field has a very complicated structure.

The Shrewsbury or Central Shropshire Coalfield

This little field with its three seams, having a total thickness of six feet, may be mentioned here because it seems to represent the southernmost extension of the Cheshire basin, and the Coal Measures are resting on the ancient rocks of the Welsh massif. Old rocks occupy the whole area southward.

Yorkshire, Nottinghamshire, and Derbyshire Coalfield

Whilst it is a common practice to regard as three fields those of West Yorkshire, South Yorkshire, and Nottinghamshire and Derbyshire, in reality the three form one huge coalfield with a common geological structure and containing for the most part the same types of coal, though changing gradually from 500 types in the north to 900 in the south. The whole area, it is true, is divisible into a western visible coalfield, and an eastern concealed coalfield where the Coal Measures are covered by Permian, Trias, and later rocks. There is a certain geographical distinction between the three areas, the West Yorkshire coalfield being associated particularly with the

woollen manufacturing area of the West Riding, with its centres at Leeds and Bradford; the South Yorkshire being associated particularly with the steel and engineering industries of Sheffield and Rotherham; whilst the Derby and Nottinghamshire coalfield—the southern portion—is associated with more isolated industrial centres such as Nottingham, Chesterfield, and Mansfield. The limits of the concealed coalfield, especially to the north-east, are as yet unknown; but the total known area of the field exceeds 2,300 square miles or more than twice the size of the South Wales coalfield, and the field as a whole undoubtedly has the greatest reserves of any British field, exceeding in this respect even the rich South Wales field. The Coal Measures of the fields on the eastern side of the Pennines are less disturbed than those on the western side (Lancashire and North Staffordshire), and this is true of the great coalfield of Yorkshire, Nottingham, and Derby. The Coal Measure rocks dip gently away from the Millstone Grit areas of the Pennine Uplift. Consequently, there is a long band of Lower Coal Measures exposed in the extreme western part of the field. As usual in the Lower Coal Measures, the coals are on the whole few and poor, but in Yorkshire, the Ganister Coal has been extensively mined between Sheffield and Huddersfield, as well as around Halifax, though largely in connection with the underlying ganister and associated fireclays which afford high-class refractory materials of world-wide reputation. Then the Kilburn Coal of the Lower Coal Measures is famous as an almost ash-free house coal. This appears particularly in the southern part of the field and is scarcely recognisable in Yorkshire, where, however, around Bradford, Leeds, and Wakefield, the Better Bed Coal is one of great purity, and formerly much used for iron smelting. Around Leeds the Beeston coal, formed by the union of two coals, is occasionally as much as eight feet thick, and is one of the most valuable seams in West Yorkshire. But on the whole it is the Middle Coal Measures which contain the most seams, and in which the formation of coal reaches its maximum development as regards thickness, quality, and the persistence of the individual seams. The famous Silkstone seam, the chief gas and coking coal, also well

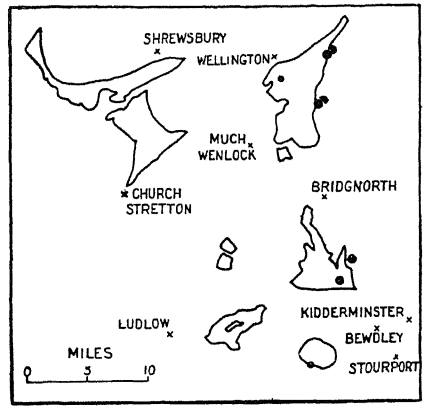


FIG. 157.—The Shropshire Coalfields, 1950

Coalbrookdale and Ironbridge (p. 311) lie north-east of Much Wenlock

known as a house coal, is taken as the base of the Middle Coal Measures; whilst an almost equally famous seam, the Top Hard Coal of Nottinghamshire (known as the Barnsley coal in the Barnsley area) can be regarded as dividing the Middle Coal Measures into two parts. It is only in the extreme north of the field that the

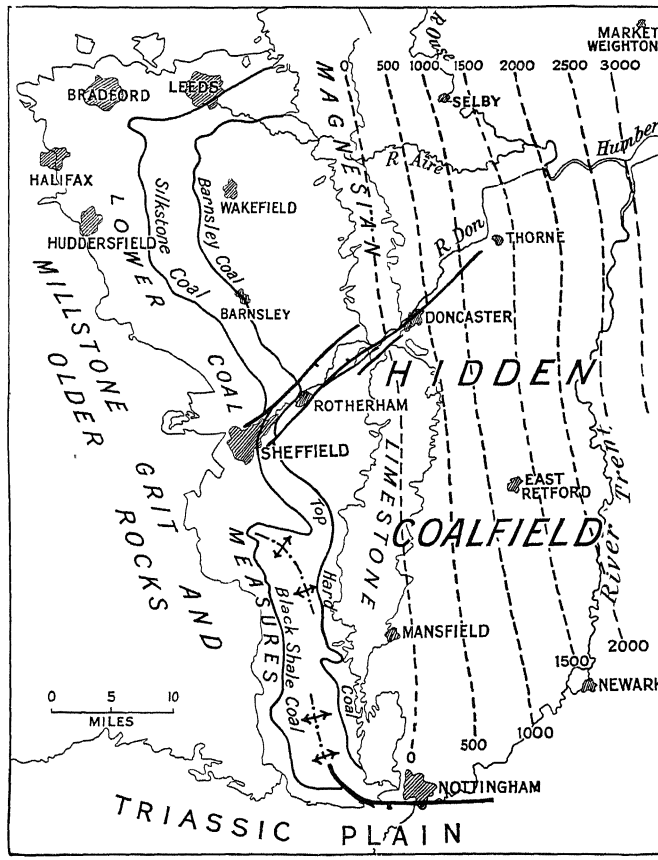


FIG. 158.—Map showing the extent and major features of the Yorkshire, Nottinghamshire, and Derbyshire Coalfield

There is a southern extension of the hidden field under the Triassic Plains. The broken lines to the east indicate the depth in feet below sea-level at which Coal Measures are reached

Barnsley coal deteriorates and passes into the Warren House coal. High dips amongst the coal seams are the exception in this great field, and are limited to a few restricted areas. Consequently mining operations are carried on with a greater facility than in any other British coalfield. As shown in the sectional diagram there are local anticlinal folds, especially in the south, and notably the Brimington anticline near Chesterfield and the Erewash anticline between Alfre-

ton and Ilkeston, but on the whole faulting on an extensive scale is much less noticeable in this field than in most British fields. One of the most important groups of faults are those known as the Don faults, and it is seen that a trough is formed between the two main faults, and along this trough zone the Don itself runs. As one passes

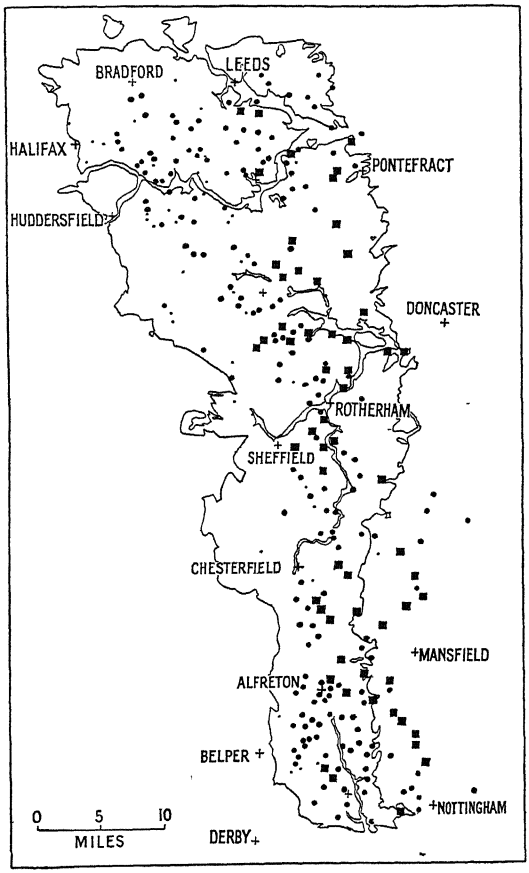


FIG. 159.—The Yorkshire, Nottinghamshire, and Derbyshire Field, 1900

Square dots=collieries employing more than 1,000 men Large round dots=collieries employing 100 to 1,000. Small dots=collieries employing less than 100. Note that there are only 11 large collieries in the hidden field

eastwards into the concealed coalfield, the cover of Permian and Triassic rocks gradually increases in thickness, so that along the line of the River Trent there is an overlying thickness of more than 2,000 feet of strata to be penetrated before the Coal Measures are reached. A boring at Market Weighton passed through 3,100 feet of the covering rocks without reaching the Coal Measures. Underlying this

cover of Permian and Trias, it is found that the Coal Measures lie in a gently folded basin, so that as one goes eastwards, the lower part of the Middle Coal Measures, Lower Coal Measures, and finally the Millstone Grit are the rocks reached beneath the cover of later strata. Later investigations including borings carried out during the Second World War show the presence of an anticline and a further eastern extension of the field, even beyond Lincoln Edge.

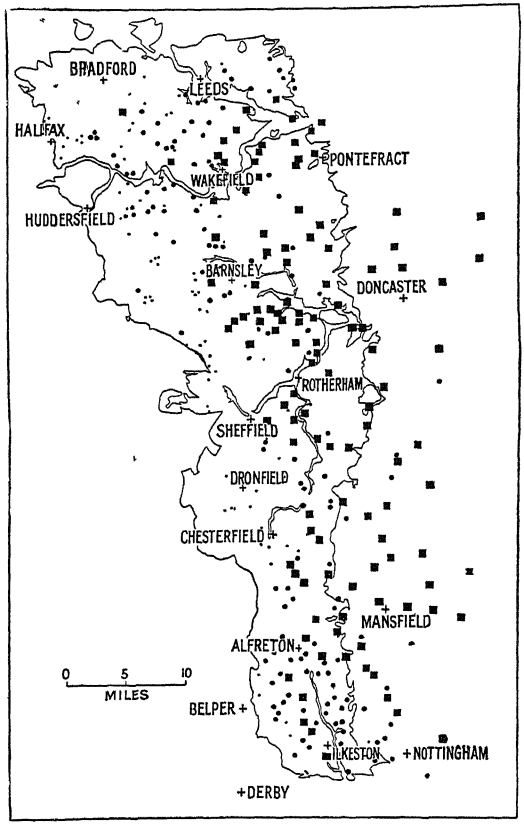


FIG. 160.—The Yorkshire, Nottinghamshire and Derbyshire Field, 1931

The Upper Coal Measures occupy a very restricted area in the whole great coalfield, but this is not of great importance since the most important seams are in the Middle Coal Measures. But even if one takes the area over which the workable Barnsley or Top Hard coal is known in the concealed portions of the coalfield, it is found that this seam alone exists over 600 square miles, and contains at least 2,000,000,000 tons of high-class coal within a depth of 3,000 feet from the surface. The high commercial value attached to this

particular seam depends particularly on the presence of a hard semi-anthracite coal, known as "hards" or "hard coal," furnishing a really first-class steam coal; whilst other parts of the seam yield a house, manufacturing and, to a less degree, gas coal. In Nottinghamshire this seam varies from a little under three to a little over six feet in thickness, with an average for the proved area of four

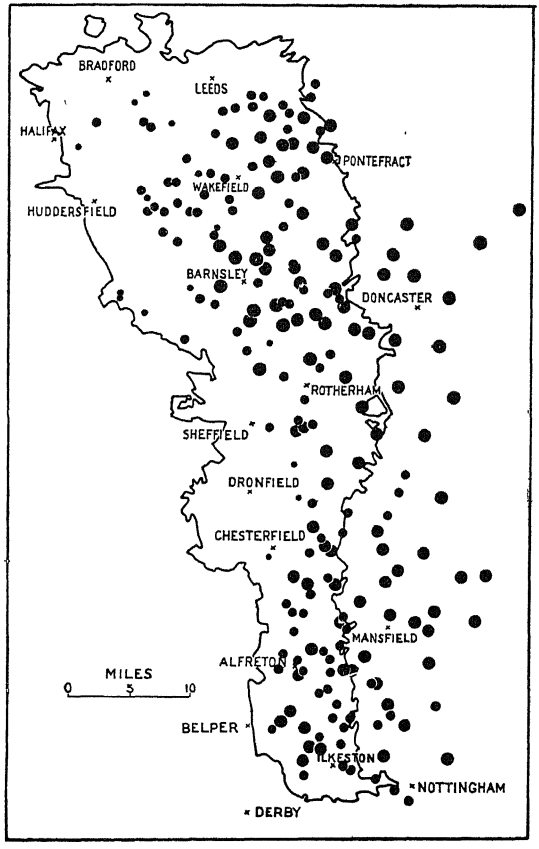


FIG. 161.—The Yorkshire, Nottinghamshire, and Derbyshire Field, 1950

There are no less than 33 large collieries in the hidden field. Note especially the development round Doncaster and in the Dukeries east of Mansfield

feet of good coal; whilst in Yorkshire an average thickness of six feet can be reckoned. If one examines the three maps, Figs. 159 to 161, showing the distribution of the collieries in the whole coalfield in the years 1900, 1931, and 1950, it will be noticed that there is, just as in Northumberland and Durham, a belt of small workings occupying the western exposed parts of the coalfield. Here, as in the more northern field, workings are shallow and the seams

largely worked out, working faces are too frequently at a great distance from the shafts, and the undertakings must, on the whole, be described as uneconomic. But farther to the east, the concealed coalfield was not touched at all until 1859, and it is particularly in the neighbourhood of Doncaster that one has a large group of collieries up to date in their construction and equipment, and forming large units capable of working on a profitable basis. Once again

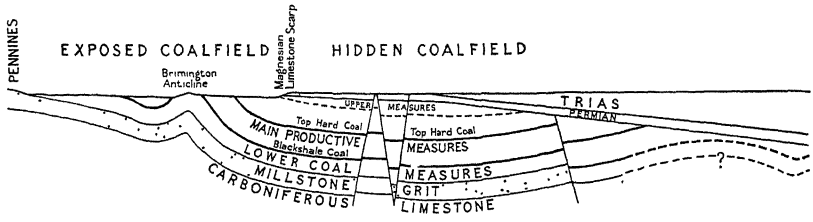


FIG. 162.—Diagrammatic section from west to east across the Derby–Nottinghamshire Coalfield

it is the larger, newer units in the eastern part of the field which must carry the older uneconomic units of the other half of the field as a permanent burden. Even in thirty years the change is remarkable, for the map shows that in 1900 there were only eleven collieries in the concealed part of the coalfield employing more than 1,000 men each; by 1931 the number had increased to thirty-five, since when there have been no additions, though two new sinkings were in progress in 1953.

The Midland Coalfields

The Midland coalfields of Leicestershire, Warwickshire, South Staffordshire, and the Forest of Wyre with Coalbrookdale have certain features in common. The Coal Measures were deposited in bays or hollows in the old land mass which we have called St. George's Land, which then stretched across south-midland England. Frequently there are no older Carboniferous rocks than the Middle Coal Measures which, therefore, rest directly on the ancient floor. This ancient floor usually slopes northwards and the Coal Measures nearly always thicken from south to north. In the northern parts of the fields there is often a considerable number of coal seams which, when traced southwards, are found to converge to form one or more very thick seams. After their deposition the structure of the fields was complicated by the formation of a very extensive series of north and south faults, and folds which also have axes running from north to south. The combined faulting and folding has resulted in the further separation of the fields into separate portions. In addition, there are frequently important east–west

faults, so that the geological structure of the small Midland coalfields is often very complicated.

(*a*) *Leicestershire.*—This coalfield lies between the old Cambrian rocks of the Nuneaton Ridge on the west and the Pre-Cambrian rocks of Charnwood Forest, north of Leicester, on the east. The coalfield includes an area of about 60 square miles in the county of Leicester together with about 15 square miles in South Derbyshire. Over this tract the Coal Measures are exposed at the surface over an area of 24 square miles with Ashby-de-la-Zouch as a centre, the most important part of the concealed coalfield lying to the south-east. The Lower Coal Measures are thin and unimportant and only one small seam has been worked. Most

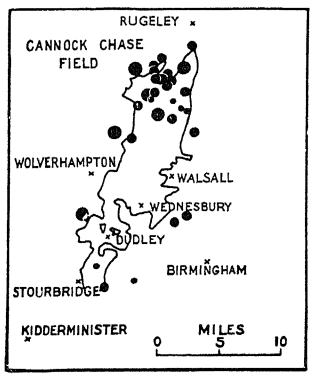


FIG. 163.—The South Staffordshire Field (including Cannock Chase, 1950). The virtual extinction of mining in the old "Black Country" should be noted

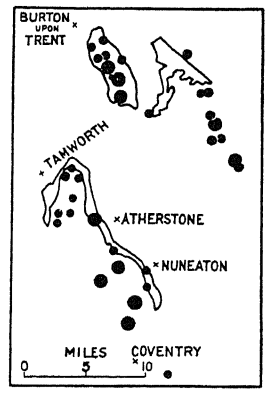


FIG. 164.—The Leicestershire and East Warwickshire Fields, 1950.

of the seams lie, therefore, in the Middle Coal Measures and occur in the eastern and western areas separated by an anticlinal fold of Lower Coal Measures. The Royster coal on the east and the Kilburn coal on the west are usually the lowest workable seams and are regarded as the base of the productive series. The Main Coal is the standard coal of the district and consists of two seams in the north which unite in the south to form one thick seam of 14–16 feet. The Main Coal is a steam, house, and manufacturing coal, the Royster for the most part a manufacturing coal. The Leicestershire coalfield is remarkable in one respect, that it has not given rise to an extensive industrial area and the coal mining centres remain small towns or often mere villages, as for example Coalville. Ashby-de-la-Zouch remains a country market town, untouched by coalfield development. Swadlincote, however, in south Derbyshire,

is an important centre of industries based on the local resources of fireclay.

(*b*) *The East Warwickshire* or *Nuneaton Coalfield.*—The total area of this field is about 150 square miles and a large part of the field is occupied by the highest and barren Coal Measures to which the productive Measures form a narrow fringe on the east and north. Again the Coal Measure rocks were deposited in an old bay. Carboniferous Limestone and Millstone Grit are nearly always absent, and the Coal Measures rest directly on the ancient Cambrian rocks. Even the Lower Coal Measures themselves seem to be absent. The Middle Coal Measures, the productive series, are about a thousand feet thick in the Tamworth area in the north, but thin southwards. As one goes southwards the coal seams tend to unite, so that in the Newdigate collieries the separate seams have coalesced to give a thickness of over 23 feet to the thick coal or the Hacksbury seams. Below this is a seven-foot coal which is known to occur all over the field. Though in the northern part of the field coal seams to a total thickness of 35 feet occur, the seven-foot coal is the thickest and the most important. The coals are bituminous coals for domestic and manufacturing purposes. With the exception of the Arley and Coventry collieries the coal pits are situated more to the northern part of the field or along the eastern outcrop, but for an area of something like 60 square miles the coals remain untouched. In this southern part of the field there is a difficulty with water in the overlying beds, but the chief obstacle in successful mining is the excessive thickness of the Thick Coal. This deserves to be stressed because it might be thought that a very thick coal would be an extremely valuable one, but the expense of timbering (or, alternately of working the coal in horizontal sections) is enormously increased.

(*c*) *The South Staffordshire Coalfield.*—The total area of this field is about 149 square miles. Again, in the southern part, the Coal Measures rest on an irregular floor usually of Silurian rocks. Structurally the field consists of two basins, on either side of a series of three periclines,[1] and the Silurian rocks are actually seen as inliers in the centre of the field and form the famous Castle Hill and Wren's Nest near Dudley, for long important because of the supply of limestone which was afforded for fluxing purposes in the days when this coalfield, under the title of the Black Country, was the centre of the iron-smelting industry of Britain. Once again the Lower Coal Measures seem to be absent, at any rate in the southern part of the field; and even the Middle Coal Measures are only 250 feet thick in the south although they thicken to nearly 2,000 feet in the north (Cannock Chase). The thinner seams in the north coalesce to form the famous Thick Coal in the south, where it occasionally

[1] A pericline is an anticline pitching at both ends and the three in the South Staffordshire Coalfield are arranged *en echelon.*

reaches 36 feet in thickness and had an aggregate thickness of over 30 feet over a considerable area. The coals of the South Staffordshire field are bituminous in character and suitable for house, manufacturing, and local uses. The seams of Cannock Chase have a specially high reputation as house coal. As in the two previous fields the boundary faults to the east and west are important, and it is not known to what depths the Coal Measures may be faulted down; there are several active pits just beyond the faults, and recent borings have proved coal in the Lichfield area. The southern part of the field, in the Black Country proper, is practically worked out and it has become usual to regard the north part as if it were a separate field under the name of the Cannock Chase field. There is justification for this on both geological and historical grounds. Transverse faults separate the two areas, to the north workings are large, deep and relatively modern whilst to the south in the Black Country they were always small, shallow pits existing from early times. There were once thousands of bell-pits and in the middle of last century there were still 400 coal pits.

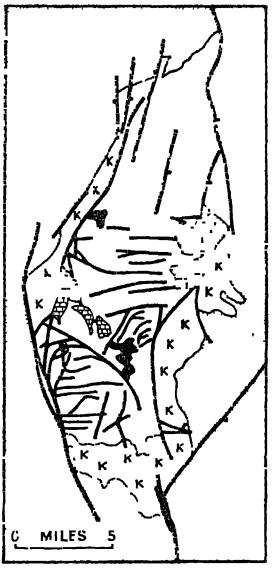


FIG. 165.—Sketch map illustrating the complicated faulting in the South Staffordshire Field

Silurian limestone is shown outcropping in the heart of the field; black areas are igneous rocks K=Keele Beds (highest carboniferous red rocks); dotted, later deposits

(*d*) *The Forest of Wyre Coalfield.*—This occupies a hollow in the ancient rocks, and although having an area of 50 square miles it has very small reserves of coal.

(*e*) *The Coalbrookdale Field.* This field has small reserves but several active collieries and is of the greatest interest because of the fame of the district in the history of the iron trade. Here coke-smelted iron was first produced, and at Ironbridge the first bridge constructed of iron was erected and is still standing (see Figs. 157 and 185).

The South Wales Coalfield

This is different from all other British fields, with the exception of its small neighbour the Forest of Dean, in that it is a true basin of wholly exposed Coal Measures. Indeed, the South Wales field may be likened roughly to a pie dish elongated from east to west and with a rim which is formed of Millstone Grit and Carboniferous Limestone, usually flanked by still older rocks. In the centre of the

pie dish there is a three-fold sequence: a Lower Series of coal-bearing rocks, then a thick sandstone usually without coal (Pennant Grits) and then an Upper Series of Coal Measures. One would expect the Coal Measures to be at the greatest depth in the centre of the pie dish. But, east of the Vale of Neath, there is an important upfold, also with an east and west direction, which brings the Lower Coal Series comparatively near the surface even in the centre of the field, and which results in the distribution of the Upper Series usually in two distinct basins in the north and south, respectively, of the main basin. The whole field has a length from east to west of about 90 miles. Its greatest width, 16–17 miles, is in Glamorganshire. An average width of about 15 miles is maintained as far as Swansea Bay. Westwards the coalfield narrows and in the western part of Pembrokeshire it is scarcely three miles across. If one includes the portions covered by the sea in Swansea Bay and Carmarthen Bay the area of the coalfield is over 1,000 square miles, and it has

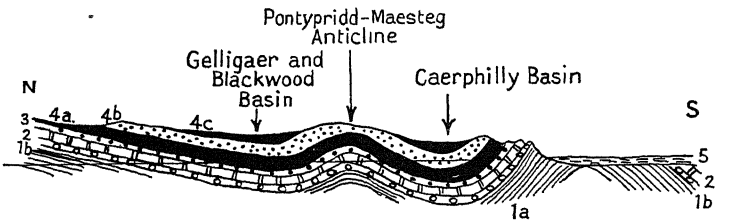


FIG. 166.—Diagrammatic section through the east of the South Wales Coal basin

1*a*, Silurian and lower Old Red Sandstone, 1*b*, upper Old Red Sandstone (conglomerates, etc.); 2, Carboniferous Limestone, 3, Millstone Grit; 4*a*, lower Coal Series; 4*b*, Pennant Grit, 4*c*, upper Coal Series, 5, Mesozoic and later rocks

very extensive reserves. The relief of the greater part of the coalfield is particularly characteristic in that deep transverse valleys have been, and to a great extent still are, the main factor determining the location of collieries, villages, and towns. In the early days levels were opened up along these steep-sided valleys, and the first mines were thus with natural drainage to the valleys. Even now shafts are usually sunk in the valleys to avoid passing through an unnecessary thickness of the Pennant Grit or other barren rock. Between the deep valleys are large tracts of moorland at a considerable elevation above sea level; and from the surface of these wide open moorlands it is often impossible to see a colliery and to realise that one is in the heart of a coalfield. Turning to details in the geological structure, apart from the large anticline which lies towards the middle of the main synclinal basin, there are other smaller anticlines which thus bring the lower coals within mineable reach. Then the whole of the main basin is crossed by a pronounced and remarkably regular series of faults trending in general from north-north-west to south-south-east. Some of these form

trough faults with "troughs" of Coal Measures let down between them, but on the whole they are thrown westwards, so that it is in the neighbourhood of Swansea that the lower coals are found at their greatest depth. In fact they are depressed below 4,000 feet and cannot under present conditions be mined. Then there is another and very important series of faults, the faults trending west-south-west, beginning particularly at the Vale of Neath and becoming more important farther westwards. Important rivers, notably the Neath, find their way along the faulted belts towards the sea. Away in the north-west of the coalfield and in Pembrokeshire folding and faulting have been very intense; frequently the beds are overfolded and there are great thrust faults, and the whole structure is such as to render mining difficult. The development of the South Wales coalfield has been influenced to a very large extent by the high quality and the

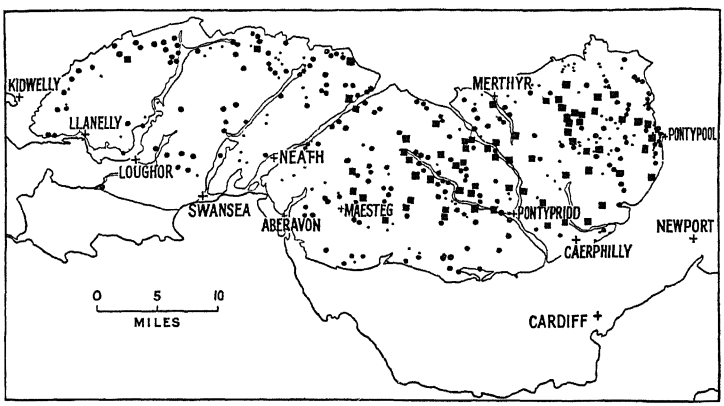


FIG. 167.—The South Wales Coalfield, 1931. Excluding the western extension

variety of the coal. Whilst bituminous coals are present in quantity there are the well-known steam coals and anthracites, both of which are characterised by a high percentage of carbon and a low percentage of volatile matter. In many South Wales coals, in addition, the ash is very small in amount. This is particularly so in the anthracite. Whilst bituminous coals commonly have an ash content of five to ten per cent., that of the steam coal of South Wales is frequently under four per cent., and in the case of the anthracite it is only about one per cent. Anthracite is found in the detached portion of the coalfield, in Pembrokeshire, and also in the north-western part of the main field from the Gwendraeth Valley approximately as far as the head of the Vale of Neath. The seams are in the Lower Coal Series. Eastwards and southwards towards Pontypool and towards Bridgend the anthracite seams change in character, each seam passing first into a steam coal and then into a bituminous coal. Thus towards the south crop of the coalfield from Swansea to near Newport

the seams in the lower part of the Coal Measures are bituminous, whilst between this area and the anthracite district they are mainly steam coals of various grades. It is particularly around Aberdare and in the Rhondda Valley, that the most famous of the steam coals have been mined. The coals of the Upper Series are generally bituminous coals. Broadly speaking, about 50 per cent. of the coal available in South Wales is steam coal, about 30 per cent. bituminous, and about 20 per cent. anthracite. Coal was undoubtedly worked in the South Wales field as early as the thirteenth century, whilst towards the end of the sixteenth century it was being used for the smelting of copper at Neath (see p. 436). For some considerable time most of the working in the northern part of the field was done by what is called "patching"—digging the nearly horizontal seams in open workings. This was succeeded by workings in bell pits, the

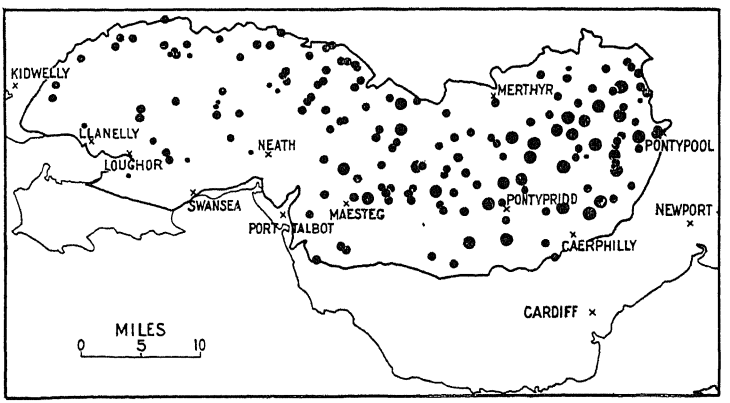
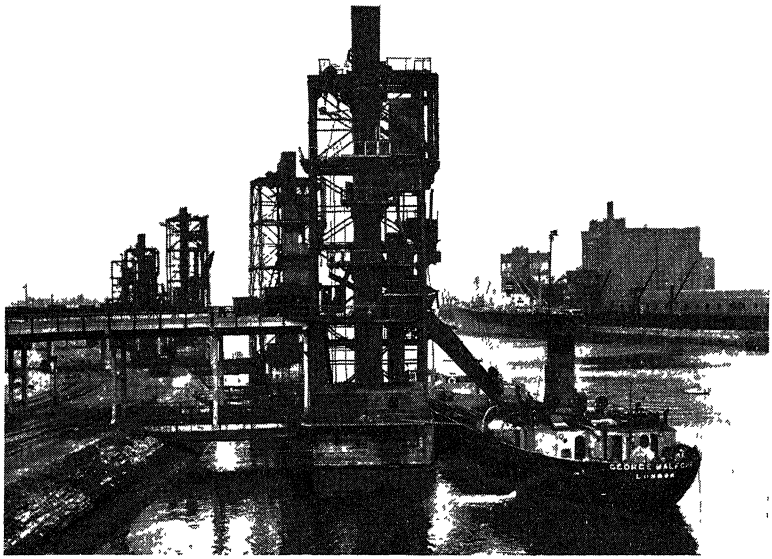


FIG. 168.—The South Wales Coalfield, 1950

Note the effect of the median anticline in the disposition of the collieries and also that the northern Lower Coal Series outcrop belt is now almost worked out after a life of over 200 years

shallow pit being dug near the outcrop of the seam, and workings being made outward from it in all directions until it was considered unsafe to proceed farther. As the collieries and workings became deeper, mining became unpopular; so that in the seventeenth century it was not uncommon for criminals to be pardoned by the king on condition that they would work for five years in the mines. In the latter part of the eighteenth century coal began to be used generally in the iron industry and there followed the great expansion in the export trade in iron. In due course this was followed by the export of coal. A detailed map of South Wales will show the way in which the valleys in the south-east of the field join and lead to two main centres—Newport and Cardiff. The coal export trade of Newport developed particularly after the opening of the Monmouthshire Canal, and the quantity exported rose from about 10,000

tons in 1798 to no less than 148,000 tons twelve years later in 1809. Some years afterwards Cardiff developed as an exporting port, but not before Swansea had attained great importance. Tramways and canals brought the coal to the ports, and the construction of the Taff Vale railway (completed in 1841) to Merthyr and Aberdare helped greatly in the development of the export trade, whilst the opening of the Bute Docks at Cardiff in 1839 was a very important factor.



[*Photo Docks and Inland Waterways: British Transport Commission*

FIG. 169.—View of Barry Docks, showing facilities for coal export

A collier being loaded through automatic coal shutes; in the background is a flour mill for handling imported grain

Of the coal raised in South Wales at the present time, some is used locally, much goes east by rail to London and elsewhere, and a considerable quantity goes to the manufacture of coke for metallurgical works. In 1913, however, no less than 70 per cent. of the total output was exported either abroad or to other parts of Britain by water. The prosperity of the South Wales coal industry has thus depended to a great extent on the export trade. The field suffered correspondingly in the inter-war years from the diminution in that trade. Cardiff, including Penarth and Barry, is easily the most important port and ships some 60 per cent. or more of the coal; followed by Newport, Swansea, and Port Talbot. The two remaining ports, Llanelly and Milford, handle comparatively very little.

The Forest of Dean Coalfield

The small Forest of Dean coalfield is composed of entirely exposed Coal Measures surrounded by a rim of Carboniferous Limestone and separated from the South Wales field by a broad expanse of older rocks. The Coal Measures occupy an area of about 44 square miles and the total thickness of the Measures is about 1,400 feet. There are several coals which are extensively worked, the three main centres being the towns of Coleford, Cinderford, and Lydney.

FIG. 170.—The Forest of Dean Coalfield, 1950

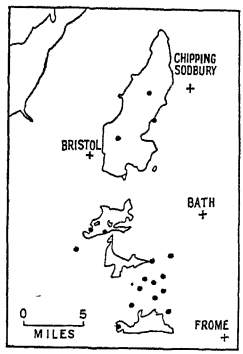


FIG. 171.—The Bristol and Somerset Fields, 1931

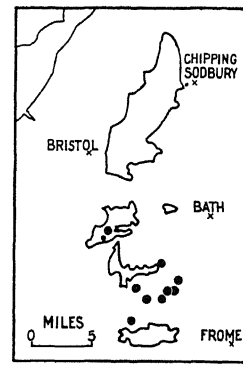


FIG. 172.—The Bristol and Somerset Fields, 1950

Somerset and Gloucestershire Coalfields

In Somerset and Gloucester there are six detached areas of Coal Measures completely different from the South Wales field in that each is surrounded by strata newer than the Coal Measures, except where a rim of Carboniferous Limestone exists (for details, see Chapter III and Fig. 35), and most of the coal mining is carried on under the newer formations. Four-fifths of the coalfield can actually be described as concealed. The exposed rocks occupy about 50 square miles, the concealed Measures about another 190. The coal seams are worked in three main areas. In the south there is a total thickness of about 23 feet of coal, slightly farther north in the Radstock area the seams increase in number and thickness, whilst the northern or Kingswood field is poorer. Geologically the fields are interesting in that some of the coals are believed to be of much younger date in the Coal Measure sequence than those in other parts of England.

The East Kent Coalfield

Long before the end of last century geologists confidently predicted that a concealed coalfield would be found underneath south-eastern England. Prestwich and Godwin Austen in particular in the 'seventies of last century were certain of the matter. The field was first discovered when excavations for the proposed Channel tunnel near Shakespeare Cliffs, Dover, were temporarily suspended

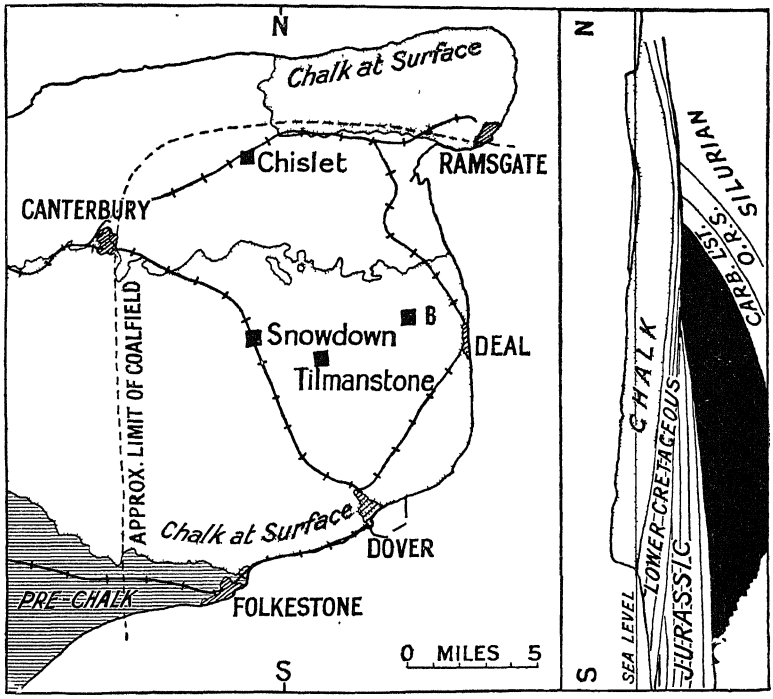


FIG. 173.—The East Kent Coalfield and a section through it with the Coal Measures in black)

The area with a stippled margin is where chalk outcrops at the surface. The four collieries are those working in 1950. B=Betteshanger

and engineers bored downwards This occurred in 1890. During the succeeding 25 years a number of boreholes were put down and the limits of the coalfield broadly determined. It forms a basin extending as far north as Sandwich, a little north of Canterbury, and westwards is bounded by a sharp fold, so that there is a rough north–south line limiting the field a short distance west of the longitude of Folkestone. It is now estimated to have an area of 206 square miles, of which 56 square miles, however, lie at a

workable distance from the shore but below the sea. Financial mismanagement—the floating of a large number of companies of doubtful standing—was responsible for the field getting a bad reputation in its early days. The coal is undoubtedly there, and there are active coal mines at Chislet, Snowdown, Tilmanstone, and Betteshanger. The field is conveniently situated for the port of Dover, and an overhead ropeway was installed to take coal in limited quantities to that port.

The Scottish Coalfields

The Scottish coalfields have been left for consideration until last because they differ very much in character from those of the rest of Britain in that the coal seams occur not only in rocks of Coal

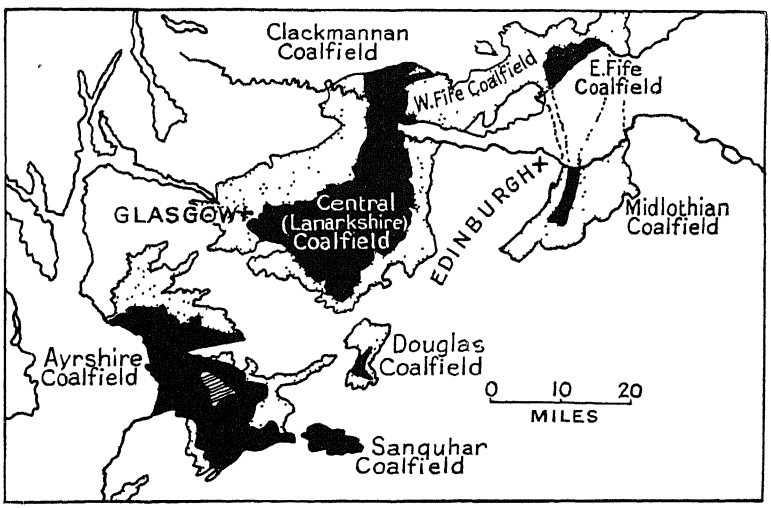


FIG. 174.—The Scottish Coalfields

The Coal Measure fields are shown in solid black; the Carboniferous Limestone fields are dotted. All the fields are basins, wholly exposed except where the eastern field is covered by the waters of the Firth of Forth and where a patch of Permian occurs in the heart of the Ayrshire field

Measure age but also in rocks which are contemporaneous with the great mass of the Carboniferous Limestone developed in England. Most of the Carboniferous Limestone coals are in the middle subdivision of that series, known as the Limestone Coal Group. Geologically, of course, the whole Midland Valley of Scotland is a broad syncline of sedimentary rocks let down between the older rocks of the Highlands on the north and of the Southern Uplands on the south. Broadly speaking, the youngest rocks are near the centre of the syncline, the older rocks along its margins. Consequently there

is a broad belt of Old Red Sandstone along the northern margin and a narrower, less continuous, belt along the south. Carboniferous rocks occupy the centre, but it is clear that folding and denudation had gone on before the formation of the Coal Measures and, at least in some cases, the Coal Measures occupy basins filling up old hollows in the pre-existing floor. Most of the ten more or less well-defined basins occupied by Coal Measures are, however, folds within Carboniferous rocks which have been formed by subsequent earth movements. The extent of the fields is roughly

FIG. 175.—The Ayrshire Fields, 1931, distinguishing the Coal Measure fields from the here unimportant Carboniferous Limestone fields. One important colliery should have been shown in the Sanquhar basin

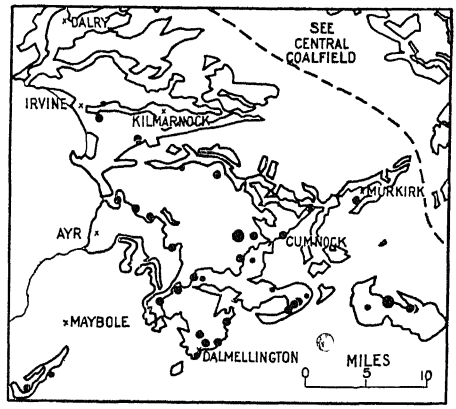


FIG. 176.—The Ayrshire Fields, 1950

shown in the accompanying diagram, and broadly speaking it can be seen that there are three important areas:

(*a*) The Ayrshire coalfield.

(*b*) The Central coalfield, lying largely in Lanarkshire, but with extensions northwards into Stirling and Clackmannan.

(*c*) The Midlothian-Fifeshire coalfield, where actually the Coal Measures as well as the Carboniferous Limestone are continuous under the Firth of Forth which, however, divides this area into two fields, the one to the south and the other to the north.

Few of the Scottish coal seams have a wide lateral extent. This is particularly the case with the Lower Group. Further, individual seams tend to vary greatly in thickness, often within short distances. Some of the best coals average under three feet in thickness, but locally the seams may swell out to over 20 feet. Most of the Scottish coals are bituminous coals, though first-class steam coals are present,

and there are good bunker coals. There are, in addition, a number of good gas and coking coals.

(*a*) *The Ayrshire Field* was formerly worked mainly in the north around Kilmarnock and Ardrossan, but the field as a whole has not given rise to extensive industrialisation.

(*b*) *The Central Field* is worked mainly north-east of the Clyde itself and the iron and steel industry, now depending largely on

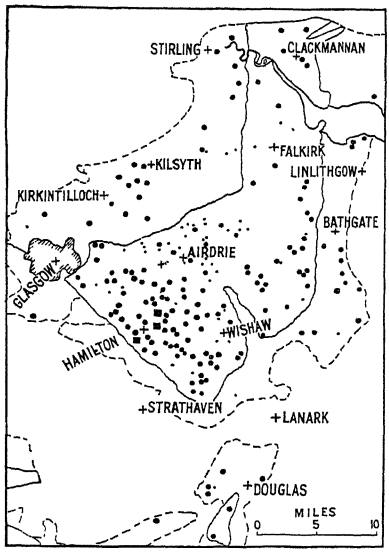


FIG 177.—The Central Coalfield, 1931

This map shows by a solid line the boundary of the upper (Coal Measure) coal-bearing series and by a pecked line the boundary of the Carboniferous as a whole Fig. 178 shows more exactly the outcrops of the two coal-bearing series

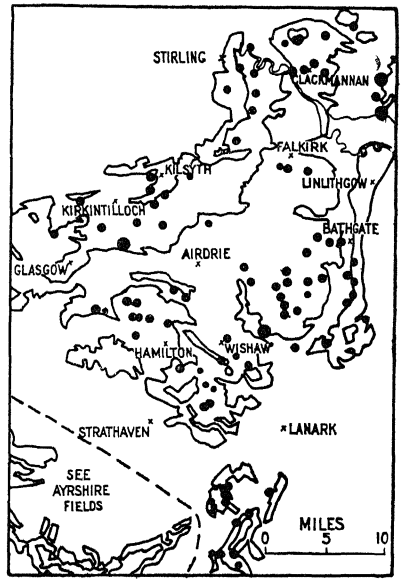


FIG. 178.—The Central Coalfield, 1950

The rarity of large collieries employing over 1,000 men is remarkable This map shows that the Carboniferous Limestone coals whilst important are not worked by nearly as many collieries as the Coal Measure coals

imported ore and pig iron, is concentrated in Airdrie, Coatbridge, Motherwell, and Wishaw. Falkirk lies in the Stirlingshire extension of the Lanarkshire field. The ancient ports of Bo'ness and Grangemouth serve the Clackmannan coalfield by shipping coal and importing pit props. Clackmannan is still largely an agricultural county and the mine workings there do not unduly obtrude themselves.

(*c*) *The Fifeshire Coalfield* yields over a quarter of Scotland's annual production, and from the point of view of reserves occupies an even more significant position and there have been important recent developments. Burntisland and Methil are both coal ports, and two of the chief industrial towns are Kirkcaldy and Dunfermline (see Chapter XXII).

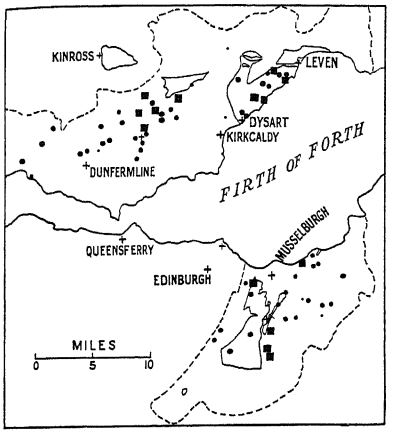


FIG. 179.—The eastern coalfields of Scotland, 1931

The importance of the lower group (Carboniferous Limestone group) in Fifeshire is very apparent

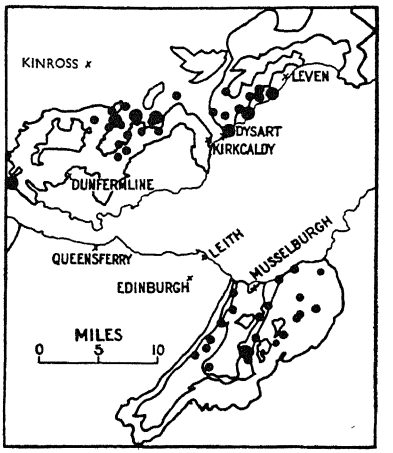


FIG. 180.—The eastern coalfields of Scotland, 1950

(*d*) *Lothian.*—The Lothian (Midlothian) coalfield lies to the east of the capital. The coals of the Coal Measures are gently inclined, those of the Lower Series tend to be steeply inclined—almost standing on edge—hence the name Edge Coal Group.

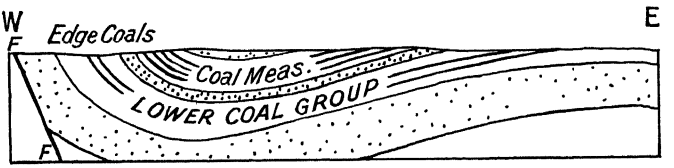


FIG. 181.—A section across the Midlothian Coalfield

Northern Ireland

Coalfields occur beneath the basalt rocks in a continuation of the rift valley of Scotland. There is a proved coalfield to the immediate west of Lough Neagh, another one is believed to exist in the neighbourhood of Larne. One has also been proved to occupy a synclinal hollow in the old highland rocks in the neighbourhood of Ballycastle, and probably similar basins occur near Portrush. Actually, however, the present production of coal is negligible and the quality of proved seams is poor. Perhaps the greatest possibility for the future is the development of electricity from powdered coal at the mines.

The Irish Republic

Although a geological map shows several areas of Coal Measures the coal seams in them are unimportant, and practically all the

coal required by the Irish Republic has to be imported—mainly from Britain.[1]

THE CHANGING USE OF BRITISH COAL

In 1913, when British coal production reached its peak of 287,000,000 tons the country was producing more than one-fifth of all the coal mined in the world. During the inter-war years with a world output approximating to 1,500,000,000 tons a year, the United States was mining roughly one-third, Great Britain one-sixth, and Germany rather less than a sixth. In 1913, almost exactly one-third of the total mined was sent out of the country as export and bunker coal; an all-time maximum export of 97·6 million tons was reached in the boom-year of 1923 or over 35 per cent. of the output. During the Second World War, the total of export and bunker coal fell to less than 3 per cent. of the coal mined and in the years following the war, from 1946 to 1952, recovered to barely 10 per cent.

The table on p. 327 shows, as one would expect with an increasing population, a steady rise in the total home demand for coal. Considering only the coal retained for home use, the following table shows, in percentages, the changes in use to which it is put.

User	1923	1938	1950
Collieries	9·6	6 9	5·3
Railways	7·9	7 5	7 3
Coastwise bunkers	0 8	0 7	0 5
Gas works	9·9	10·9	13·1
Coke ovens	11 2	10 9	11·3
Electricity works	4·1	8 4	16·5
Miners Coal	3·7	2 6	2·5
Domestic	52·8	26·1	16·3
Industrial		26·0	27·2

This table shows a large increase in the coal consumed by gas works and an enormous increase in that used by electricity works. The number of units (Kwh) of electricity sold in 1923 was 4,500 million; by 1950 this had increased to 46,000 million. Fortunately efficiency of generation has been greatly increased. In 1923 more than 3 lb. of coal was used to produce one unit of electricity; in 1950 only 1·4 lb. Increased use of electricity explains the lower proportion of coal as such used by the collieries and the railways. The big drop from 1938 to 1950 in domestic consumption is due to rationing, but the domestic consumer uses so much more gas and electricity that the total of coal required for homes is the same in 1950 and 1938—between 61 and 62 million tons.

[1] Commission of enquiry into the Resources and Industries of Ireland: Memoir on the Coalfields of Ireland, 1921.

COKE

Domestic coke is a by-product of the gas industry (see Chapter XXII), and as such is produced by almost every gas works up and down the country. Metallurgical coke, however, is produced by coke-oven plants for use in iron and steel works, and the industry has an interesting geographical pattern which may be briefly analysed.[1]

Coke for iron-smelting was probably first made by Abraham Darby at Coalbrookdale in the early part of the eighteenth century. He used lump coal of relatively low rank (78–79 per cent. carbon) and almost completely free from sulphur, and carbonised it in open heaps. This method, with similar coals, became standard practice in the Black Country and elsewhere during and after the Industrial Revolution. Then, towards the middle of the nineteenth century, the "beehive" oven was developed to use the "smalls," or "slack," of strongly swelling, "caking" coals of higher rank (carbon 85 per cent. or more). Progress in this case was most rapid in the Durham coalfield, which was particularly rich in such coals and which lay in such close proximity to the rapidly growing iron town of Middlesbrough; but the coking coals of Yorkshire and Derbyshire were also coked in beehive ovens. For various reasons the development of the by-product recovery oven was slow in Britain compared with the Continent. There was an abundance, in certain areas, of coking coals of superlative quality, and the relative stagnation of the iron and steel industry during the last quarter of the nineteenth century did not encourage high capital outlay on new coking plant. In 1900, 80 per cent. of British coke was still produced from beehive ovens, and only 8 per cent. from by-product ovens. But by 1914 the beehive percentage had dropped to 31 and the by-product figure had risen to 62, and after the First World War the beehive oven rapidly became almost extinct. By-product ovens, using crushed or slack coal of similar quality to that used for beehives, yield considerable quantities of tar, benzole, benzene, naphtha, ammonia and many other products which make coke production a chemical industry of some importance. Nevertheless the main function of the coke-oven is still to produce coke for iron-smelting.

The modern coke industry is located in two types of situation—at or near the collieries which produce coal of suitable quality, and alongside iron and steel works. Only a few of our coalfields and coal seams yield coal of suitable quality—though with the development of scientific blending the range is increasing—and in consequence the coalfield coke industry is located in three main areas

[1] S. H. Beaver, "Coke Manufacture in Great Britain: a study in industrial geography", *Inst. Brit. Geog.*, Publ. No. 17, 1951, 131–148.

only, in south Durham, in south Yorkshire and north-east Derbyshire, and in eastern South Wales. In addition to these pit-head cokeries, however, vast quantities of coke are now made at "integrated" iron and steelworks (*v. inf.*, p. 374), both on the coalfields —as at Rotherham, Stoke-on-Trent, Glasgow and Ebbw Vale— and away from the coalfields—as at Middlesbrough, Scunthorpe, Corby and Cardiff—for coke is more expensive to transport than coal, and the "waste" gases from the ovens can be used in the works for various power-producing purposes as well as for their by-products. In those areas where coke is made the gas is frequently used to supplement the local gasworks' output for domestic and industrial use. The Sheffield area actually has a "gas-grid" on the same general principle as the electricity "grid."

The annual output of metallurgical coke is roughly 14 million tons, produced from about 20–21 million tons of raw coal.

THE BRITISH COAL TRADE

In the present century coal has been the one primary commodity of which Britain has had a large exportable surplus. In addition to a large coastwise movement, which is the cause of much of the activity of the ports in the coal-producing areas, shipments of coal destined for consumption outside the country may be divided into two categories: true exports to be unloaded at foreign ports and bunker coal for consumption by vessels en route. Since both are regarded as exports, they are shown together in the table on p. 327. This table reveals some surprising facts. In 1913, the year of peak production, no less than 94·4 million long tons, or nearly one-third of the total output, were exported. During the First World War exports dropped sharply, reaching the low figure of 40·5 million tons in 1918, the year when the German submarine campaign was at its height. When the war ended, Britain's coal markets were completely changed. Polish "reparation" coal has often been blamed for the troubles, but a comparison of the 1913 and 1920 customers for British coal shows that the loss in markets was world-wide and that the drop was fairly small in the countries receiving reparation coal. Between 35 and 40 per cent. (see table) of the exports came from South Wales—mainly hard steam coals for bunkers and for the coaling stations of the world. Two changes, however, had taken place during the war: many ships had been converted to oil burning; and the more distant coaling stations— Panama, Cristóbal, Port Said, Suez, Aden, Colombo, and Singapore —had come to rely on other, usually more local, supplies. Countries that had formerly depended on British coal for their factories had not only developed home resources or turned to other supplies but had also developed hydroelectric power. The rise in exports

in the "boom years" 1922 and 1923—reaching the all-time maximum of 97·6 million long tons in 1923—was due largely to the European demand for general-purpose coals, and thus South Wales had a

NET EXPORTS OF COAL FROM GREAT BRITAIN EXCLUDING BUNKER COAL[1]

In millions of long tons

	1913[2]	1923	1929	1932	1938	1946	1951
USSR and Succession States	6·00	1·48	0·71	0·94	1·86	—	—
Sweden	4·56	3 17	2·34	1·36	2 65	0·05	0·93
Norway	2·30	1·61	1·44	0·87	1 37	0·02	0·24
Denmark	3·03	3·17	2·19	2·09	3·00	0·56	1·63
Germany	8·95	14·81	5·52	2·31	3·69	—	0·14
Netherlands	2·02	6·80	3·12	1·77	0·89	0·03	0·34
Belgium	2·03	6·51	4·14	1·59	0·66	0 09	0 37
France	12·78	18·83	13·04	8·88	6·15	0·75	0 60
Portugal	1·20	0·77	1·05	0·91	0·71	0·09	0·26
Spain	2·54	1·15	1·75	1·08	1·00	0·08	0·36
Italy	9·65	7 61	7·10	5 05	2·26	0·11	0·53
Austria-Hungary	1·06	—	—	—	—	—	—
Greece	0·73	0 46	0·60	0·17	0·14	—	—
Algeria	1·23	1·06	1·81	1·22	0·89	0·25	—
Irish Republic	—	1·48	2·46	1·93	2·48	1·28	1·16
Channel Islands	0·17	0 16	0·21	0·21	0 26	0·15	0·20
Gibraltar	0·35	0·45	0·35	0·20	0 41	0·21	—
Malta and Gozo	0·70	0·30	0·18	0·09	0·08	—	—
Egypt (inc. Sudan)	3·16	1·70	2·30	1 28	1·58	0·02	0·03
Other European and Mediterranean countries	0·88	0 70	1·03	0·76	0·60	—	0·10
Canary Islands	1·16	0 61	0 46	0 28	0·06	—	—
Azores and Madeira	0·15	0 07	0·07	0·05	0·05	—	—
French W. Africa	0·15	0 14	0·21	0·08	0·13	0·07	—
Portuguese W. Africa	0·23	0·24	0 30	0·07	0·11	—	—
Aden and Dependencies	0·18	0 06	0·06	0·02	0·01	—	—
British India and Burma	0·18	0·08	0·02	0·01	—	—	—
Ceylon	0·24	0·17	0·11	0·04	—	—	—
Straits Settlements	0·03	0·02	0 09	0 04	0·01	—	—
Hong Kong	0·05	0·02	—	0·02	—	—	—
Other African and Asiatic countries	0·43	0·28	0·37	0·13	0·17	0·20	—
Chile	0·59	0·02	0·04	—	—	—	—
Brazil	1 89	1·15	1·81	0·81	0·53	0·01	—
Uruguay	0·72	0·41	0·40	0·30	0·23	0·01	—
Argentina	3·70	2·46	2·80	1·85	2·03	—	0·43
Other S American countries	0 06	0·12	0·23	0 01	0 02	—	—
Canada	0·03	0·37	0·74	1·61	1·13	0·09	0·28
Newfoundland	0·06	0·05	0·02	0·14	0·16	0·01	—
United States	—	0·75	0·33	0·23	0·13	—	0·02
British W. Indies	0·02	0·05	0·05	0·02	0·07	—	—
Other North and Central American countries	0·05	0·05	0·02	0 02	0 02	—	—
Other countries	0·12	0·12	0·74	0·13	0 23	0·18	0·33
Total	73·38	79·46	60·27	38·90	35·86	4·45	7·95

[1] This table is compiled from unpublished statistics supplied by the National Coal Board and differs from others based on less comprehensive information.

[2] Exports from Great Britain and Ireland, exclusive of shipments between Great Britain and Ireland.

smaller proportion of the trade. The disastrous strikes of 1926 lost Britain other markets, never fully regained, with the result that exports in the 1930's remained almost steady around the 50-million mark, but dropped from 25 per cent. to 20 per cent. of the output. The export of 46·5 million long tons in 1939 was almost exactly 20 per cent. of the output.

CLASSIFIED EXPORT OF COAL FROM BRITAIN (EXCLUDING BUNKER COAL)
In millions of long tons

	1913	1923	1929	1932	1938	1946	1951
Anthracite.	3·0	3·18	4 22	3·90	3·56	0 96	1·09
Steam . .	53·6	58·94	40·81	26·05	23·81	2·18	5 27[1]
Gas . .	11·5	9·10	7·32	4·21	3·84	0 05	1·33
Household.	1 8	1·45	1·85	1·41	1·51	0·06	—
Other . .	3·5	6·73	6 07	3·32	3·13	1·19	0·06[2]
Total .	73·4	79·46	60·27	38·9	35·86	4·45	7·75[3]

[1] Including Household [2] Coking [3] Excluding Channel Isles

The Second World War killed the export trade. The small figures for the years after 1940 in the Table opposite include bunker coal. Thus in 1944 the true export was only 1·6 million tons. In 1946 and succeeding years the position was entirely different. In a world hungry for coal—especially the devastated countries of Europe and such customers as Denmark and Sweden, able and willing to send much-needed foodstuffs and raw materials in exchange—Britain has a market waiting for at least 50 million tons a year but remains scarcely able to produce enough for minimum home needs, essentially because of the shortage of skilled manpower. In the very severe winter of 1946–1947, the British froze in their homes and offices, factories went on short time, no outdoor display lighting was allowed, and precious dollars were spent on imports of coal—with a 200 years' supply waiting to be mined. British miners, with the memory of the unemployment in the industry in the inter-war years, find it hard to realise changed circumstances. An output of an additional 50 million tons a year would change the whole economic position of the country. Yet in 1952, the attempt to use Italian miners had to be declared a failure, because of the unwillingness of the British miners to work with them.

The ports concerned with the coal export trade fall into six groups. In the inter-war years roughly 80 per cent. of the export was from the South Wales and North-eastern ports: now the other groups have half the trade.

1. North-eastern England ports (Newcastle-on-Tyne ports, Blyth, Sunderland, and Middlesbrough).
2. Humber ports (Hull, Goole, Immingham, and Grimsby).

GREAT BRITAIN: PRODUCTION, EXPORT OF COAL (CARGO AND BUNKER), AND HOME USE

In millions of long tons with percentages of exports from South Wales (SW) and Northumberland and Durham (N & D)

Year	Output	Export	SW	N & D	Home Use
1900	225·2				
1901	219·0				
1902	227·1				
1903	230·3				
1904	232·4				
1905	236·1	64·9			171·2
1906	251·1	74·2			176·9
1907	267·8	82·2			185·6
1908	261·5	82 0			179·5
1909	263·8	82·8			181·0
1910	264·4	81·6			182·8
1911	271·9	83·9			188·0
1912	260 4	82·7			177·7
1913	287·4	94·4			193·0
1914	265·7	77·7			188·2
1915	253·2	57·1			196·1
1916	256·4	51·4			205·0
1917	248·5	45·2			203·3
1918	227 7	40·5			187·2
1919	229 8	47·2			182·6
1920	229 5	38 8			190·7
1921	163 3	35·6			127·7
1922	249·6	82·5	37	31	167·1
1923	276·0	97·6	35	29	178·4
1924	267·1	79·3	38	31	187·8
1925	243·2	67·2	37	30	176 0
1926	126 3	28·2	39	29	98·1
1927	251 2	68·0	39	33	183·2
1928	237·5	66·8	38	32	170·7
1929	257 9	76·7	38	31	181·2
1930	243·9	70·5	38	30	173·4
1931	219 5	57·4	37	31	162·1
1932	208·7	53·1	37	29	155·6
1933	207·1	52·5	36	31	154·6
1934	220·7	53·1	35	31	167 6
1935	222·2	51·2	36	30	171 0
1936	228·4	46·5	34	30	181·9
1937	240·4	52·0	37	29	188·4
1938	227·0	46·4	37	29	180·6
1939	231·4	46·5	35	30	184·9
1940	224·3	26 6	42	25	197·7
1941	205·8	9 1	46	18	196 7
1942	204 4	7 3	49	14	197 1
1943	198·4	7·3	44	14	191·1
1944	191·8	5 6	37	9	186·2
1945	182·0	8 2	24	15	173·8
1946	188 9	8 7	28	13	182 2
1947	197 4	5 4	25	20	192 0
1948	209·4	16·1	24	24	193·3
1949	215·2	19·2	27	24	196·0
1950	216·3	16·9	31	19	199·4
1951	222 3	11·6	30	31	210·7
1952	226·5	15·6	27	28	210·9
1953	224·2	16·9	26	28	207·3

Exports from Northumberland and Durham include Cumberland from 1947 onwards.

3. Bristol Channel ports (Newport, Swansea, Cardiff, etc.).
4. North-west England ports (Liverpool, Manchester, Runcorn, Fleetwood, Workington, etc.).
5. East Scotland ports (Leith, Granton, Bo'ness, Grangemouth, Burntisland, etc.).
6. West Scotland ports (Greenock, Glasgow, Ardrossan, Troon, Ayr, etc.).

FUEL AND ENERGY PRODUCTION AND USE IN THE UNITED KINGDOM

The total quantity of fuel and energy (including water power) used in the United Kingdom in 1950 was equivalent to 223 million tons of coal. Of this quantity about 200 million tons were actually coal, representing about 90 per cent. of the whole. Approximately another ten per cent. was derived from imported oil. Water power and all other sources supplied only 0·5 per cent.

Although Britain, as indicated above, has abundant coal reserves, difficulties in working and consequent costs are certain to increase gradually. By way of contrast to coal reserves and despite oil discoveries during the Second World War, total reserves of petroleum at perhaps a million tons and of oil to be obtained from oil shale estimated at 70 million tons would provide only four or five years' consumption. Total peat reserves (probably 10,000 million tons) have been calculated as equivalent to only 20 to 25 years' consumption of coal at present rates.

The Ministry of Fuel and Power has calculated that it would only be economic within the foreseeable future to obtain energy to replace 2 or 3 million tons of coal a year from such sources as water power (including tidal energy), wind power, wood, vegetable and animal wastes and direct radiation from the sun.

Interest in wind power was revived in 1952 when the British Electricity Authority (B.E.A.) sought powers to erect wind-driven generators at Mynydd Anelog on the windy coast of the Lleyn in North Wales. In 1953 an intensive search for natural gas was also undertaken.

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P E P (16 Queen Anne's Gate, S.W.1) is an independent research organisation supported by private donations and subscriptions. It employs a staff of research workers, who are assisted by volunteer expert members, and has produced many valuable and comprehensive reports. These are always published by the association, and the names of the writers are not given. This report on the British fuel and power industries is particularly comprehensive and valuable, summarising much of the material contained in recent official publications. Statistics include those of 1945. The preceding report, "The British Coal Industry," was published in 1936.

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CHAPTER XV

MINING INDUSTRIES OTHER THAN COAL AND IRON[1]

THE table on p. 277 shows the relatively small importance, by monetary value, of minerals other than coal. Quite apart from iron ore, however, which still provides a substantial proportion of the raw material for the iron and steel industry (see Chapter XVI), some of the other minerals have an importance which is belittled in a table such as that quoted because of their low value per ton. No one will question the vital importance of limestone, for example, to the metallurgical, chemical, and cement industries and to agriculture, or of the clay which provides the bricks for building houses and factories, and it is significant, in this age of concrete, that gravel, one of the constituents of concrete, should now be the second mineral to coal in terms of tonnage raised. Whilst the "other minerals" are far below coal as employers of labour, they are as a whole far more widespread than coal and they make their mark on the landscape in no unmistakable fashion.

In general terms we can divide the "other minerals" into two groups, metallic and non-metallic. Any consideration of metallic minerals in Britain (other than iron ore) must now be largely a matter of historical geography, for, important though Cornish tin, Anglesey copper, Pennine lead, for example, may once have been, present outputs are either nil or very small in quantity. Nevertheless a brief résumé may not be out of place. The industrial significance of the minerals in question will be considered in Chapter XVIII.

METALLIC ORES

Although individual deposits may vary widely in details of their mode of occurrence most of the metallic ores found in Britain may be said to occur in one of three major types of geological environment:

(i) Associated with the granite masses of Devon and Cornwall.

(ii) In the Lower Palæozoic rocks of the Highland Zone of Britain, associated with igneous activity of which sometimes there is no evidence at the surface—as in central and North Wales (including Anglesey), the Welsh Border (Shropshire), the Lake

[1] By S. H. Beaver.

District, the Southern Uplands of Scotland, and the Wicklow Mountains of Ireland.

(iii) In certain regions of the Carboniferous Limestone outcrop, such as the Derbyshire Dome, the northern Pennines of north-west Yorkshire, Durham and Northumberland, the Mendip Hills, and the hills of north-eastern Wales (Flintshire).

(1) *Devon and Cornwall* (see also Chapter XVIII). One of the later stages of the igneous activity which produced the Armorican granites of Devon and Cornwall was the intrusion of veins and lodes carrying metalliferous ores, which are found chiefly in a belt about 6–10 miles wide extending from Lands End to Dartmoor (Fig. 182).

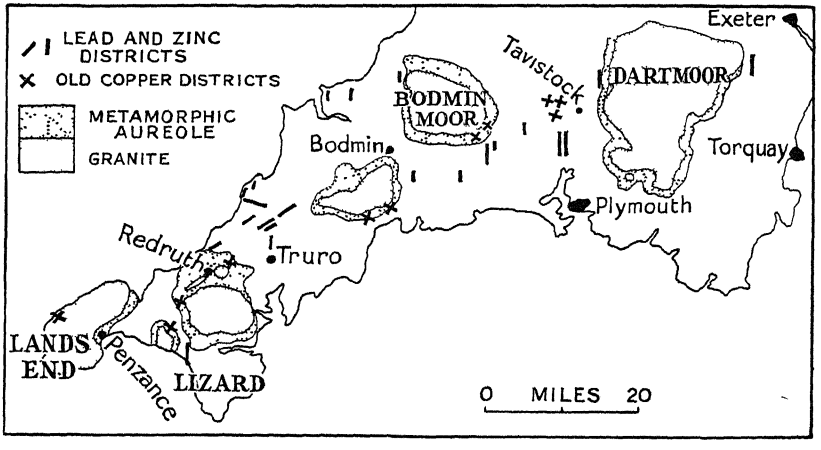


FIG. 182.—The metalliferous mineral areas of Cornwall and Devon

The tin-mining tracts corresponded approximately with the copper districts.

In general, tin and copper occur nearest to the granites, lead, silver, and zinc farther away. Tin-ore (cassiterite) is a very stable mineral and so was to be found not only in the original veins or lodes in the rocks, but also washed out in alluvial gravels, where it was formerly worked as "stream tin." Cornwall was almost the world's only source of tin from very early times until the early nineteenth century. The greatest concentration of mining was around Camborne and Redruth. Copper was also mined from pre-Roman times in several districts of the south-western peninsula, and Cornish ores contributed in no small measure to the rise of Swansea as the world's greatest copper-smelting centre in the early part of the nineteenth century (cf. p. 440). Mining in Devon and Cornwall is but a shadow of its former self; a few mines remain productive of wolfram (tungsten ore) and arsenic, but, though it is considered by some that much

mineral wealth remains to be got, there is unlikely to be any revival without an enormous programme of reorganisation and exploration and the application of vast new capital resources.[1]

(2) *Wales, etc.* The Lower Palæozoic rocks of Wales, the Lake District, the Southern Uplands, and Ireland have yielded a number of different minerals, but particularly lead which was worked from Roman times. The most important areas were in central and North Wales, in the Welsh Border district (Shelve in Shropshire), in the Lake District, and in the Leadhills district of the Southern Uplands. Copper was also occasionally important, as in North Wales and Anglesey (Parys Mountain), and in the Lake District (Keswick area). A little gold has been obtained from the Wicklow Mountains, from the Dolgelley area of North Wales and from Carmarthenshire; and the manganese ore found in the Cambrian rocks of North Wales has been worked from time to time, especially during the two World Wars.

(3) Fissures and solution hollows in the Carboniferous Limestones are frequently filled with mineral deposits, of which lead and zinc have been the more important. Five main lead-fields have been worked, in the Alston–Allendale area of the northernmost Pennines, farther south in north-west Yorkshire, in the Derbyshire Dome, in the Mendips, and in the limestone hills which border the Flint and Denbigh coalfield. In most of these areas the maximum output was reached after the middle of the nineteenth century and a very rapid decline followed; but evidence of the industry, in the shape of old mine-shafts, spoil heaps, and tumbledown buildings, is still to be found in places. Zinc ores were associated with the lead veins in some places, particularly in the Mendips and in North Wales. Occasionally, copper ores occurred, as on the western edge of the Derbyshire Dome at Ecton, in Staffordshire.

NON-METALLIC MINERALS

We may divide the non-metallic minerals into two groups, the rarer and more highly localised ones—*e.g.* salt, gypsum, and anhydrite, fireclay and ganister, fluorspar, china clay—and the commoner and more widespread ones—*e.g.* limestone, chalk, brick clays, sandstone, igneous rocks (granite, whinstone, etc.), slate, sand, and gravel. Another way of distinguishing the two groups might be to say that of the first group more or less all of the available deposits are likely to be ultimately required, whereas in general, and from a national rather than a local point of view, there is a wider choice of

[1] See "Memorandum to the Minister of Reconstruction on the production of non-ferrous metals and minerals other than coal in Great Britain," published by Institution of Mining and Metallurgy, 1944.

locality for the working of the commoner minerals.[1] One can hardly envisage the extraction and utilisation of the entire Chalk outcrop, for example!

Except for the igneous rocks, which are quarried mainly for road metal, all the non-metallic minerals occur in the sedimentary rocks, and every formation from the Cambrian to the Pleistocene yields some mineral or other in some part of its outcrop.

The following table shows the output of non-metallic minerals in a recent year:

OUTPUT OF NON-METALLIC MINERALS, 1951
(thousand tons)

Gravel and Sand	43,249	Gypsum and Anhydrite	2,284
Limestone	26,806	China clay and China stone	979
Clay and Shale	23,753	Foundry sand	695
Chalk	13,134	Silica rock and Ganister	471
Igneous rock	12,269	Ball clay	383
Salt	4,648	Slate	178
Sandstone	3,323	Fluorspar	64
Fireclay	2,367		

The "Rarer" Minerals

The semi-desert conditions under which the later Permian and Triassic rocks were laid down were responsible for the accumulations of salt, gypsum, and anhydrite which are now worked in Cheshire, in South Durham, and elsewhere.

Salt.[2] Rock-salt used to be mined in Cheshire, and still is to a very small extent, but almost all our salt output is now obtained by controlled brine-pumping.[3] There is an enormous reserve underneath the Cheshire Plain—the salt beds are several hundred feet in thickness over an area of some 375 square miles—and the great chemical industries (p. 542) which depend on the salt need have no fear of exhausting the supplies. Other salt deposits occur in the Trias in the vicinity of Stafford, Droitwich (Worcs.), Fleetwood (Lancs.), and Middlesbrough.

Gypsum[4] (calcium sulphate $CaSO_4$, $2H_2O$) is the raw material of

[1] This contrast should not be pushed too far; to an increasing extent modern industry requires specialised and standardised products which can often only be obtained from relatively small areas, and the availability of transport and markets exerts a very strong influence over the location of quarries.

[2] A. F. Calvert, *Salt in Cheshire*, London, 1915; also *Mem. Geol. Surv., Mineral Resources*, Vol. XVIII, "Rock-salt and brine," H.M.S.O., 1921.

[3] Pumping of "wild" brine from the old and flooded salt-mines led to considerable and unpredictable surface subsidence—now represented by "flashes" or lakes, especially in the Northwich district; controlled pumping does not eliminate subsidence, but reduces it and renders it more or less predictable, by confining it to the vicinity of the bore-hole. About 65 per cent. of the brine pumped in Great Britain is obtained from bore-holes on the Holford estate, about 5 miles east of Northwich.

[4] *Mem. Geol. Surv., Mineral Resources*, Vol. III, "Gypsum and anhydrite." H.M.S.O., 3rd edition, 1938.

plaster of Paris and of the plasterboard which now plays such an important part in the building industry. It is quarried or mined in Nottinghamshire (*e.g.* at Gotham and near Newark), in Staffordshire (near Tutbury), and in the Eden Valley near Appleby; there is also a mine near Battle, in Sussex, which works gypsum from the Purbeck Beds (Upper Jurassic). The anhydrous form of gypsum is known as *anhydrite*; it is an important raw material for certain branches of the chemical industry, notably the manufacture of ammonium sulphate and sulphuric acid (cf. p. 543). Almost the entire output comes from a large mine at Billingham-on-Tees, near Middlesbrough, around which, in the 1930's, the vast works of Imperial Chemical Industries grew up.

Fluorspar,[1] used as a flux in the steel industry and in the manufacture of hydrofluoric acid for glass-etching, is obtained from veins in the lead-bearing districts of the Carboniferous Limestone outcrop; the main present source is Derbyshire.

China clay and China stone[2] are derived from the decomposition (probably by superheated gases and steam from below) of certain of

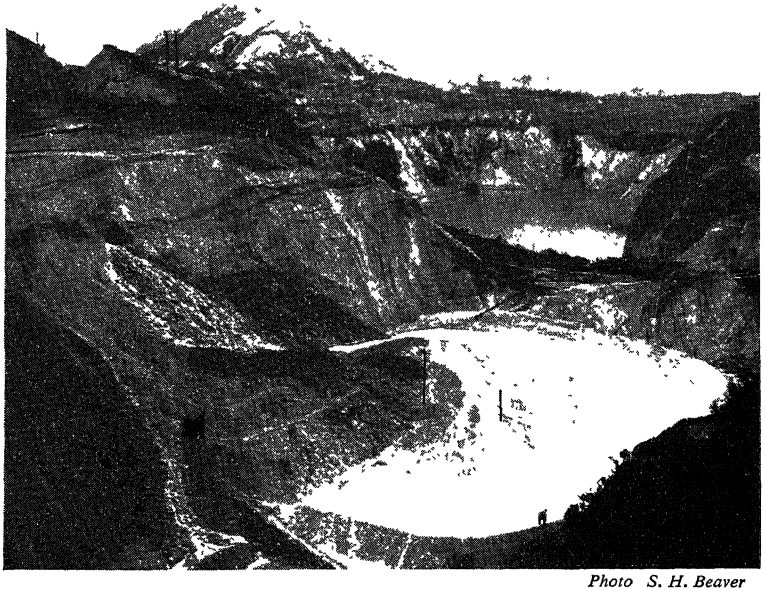


Photo S. H. Beaver

FIG. 183.—Goonbarrow China clay pit, near St. Austell

[1] *Mem. Geol. Surv., Mineral Resources*, Vol. IV. H.M.S.O., 1922.
[2] Board of Trade. Working Party Reports. *China Clay*. H.M.S.O., 1948.

the granite masses of Devon and Cornwall. By far the most important field is in the Hensbarrow granite, near St. Austell. The clay is got from deep open pits (the deepest is over 300 feet) by hydraulic sluicing, and the impurities (mainly quartz and other minerals) are removed and dumped in the gigantic white conical spoil-heaps which form the major feature of the landscape.[1] The clay is further purified and dried, and is then sent away by rail or exported coastwise and overseas from such small ports as Fowey and Par. Whilst much china clay and china stone still go to North Staffordshire for the pottery industry, and large quantities are exported to U.S.A. and other countries, it is important to realise that pottery manufacture is no longer the major user of china clay. Paper manufacture and the linoleum and oilcloth industries take considerable quantities, and so do rubber and paint manufacture, and the list of uses is extending.

Ball-clay[2] is another raw material for the manufacture of pottery, glazed tiles, and sanitary earthenware. The two principal sources are Eocene beds in the vicinity of Poole, in Dorset, and Oligocene lake-bed deposits near Bovey Tracey, in south Devonshire; in both areas there are quarries and shallow mines.

Fireclay[3] is a special kind of clay with properties of resistance to high temperatures; it is employed in the manufacture of refractory bricks for furnace linings, gas retorts, etc., and also for glazed sanitary pipes (the glazing of which needs temperatures higher than those used for ordinary brick burning). Fireclays generally occur as the seat-earths of coal seams, particularly in the Lower Coal Measures of Durham, Yorkshire, and Lancashire, in the Middle Coal Measures of the south Derbyshire coalfield (Swadlincote area), and of the Black Country, Warwickshire, and North Wales coalfields, and at the base of the Upper Coal Measures in the Potteries coalfield. In all these districts important refractory and glazed-ware industries exist; the greatest concentrations are in the Swadlincote area and in the Black Country near Stourbridge. The fireclays are generally mined, often from coal mines, but they are also sometimes quarried, as in the Potteries district.

Ganister[4] is a rock consisting almost entirely of silica; like fireclay it occurs underneath coal seams, and is used for the manufacture of refractories. True ganister is mostly obtained in the Lower Coal Measures of the Sheffield district, but somewhat similar material,

[1] Between 6 and 8 times as much waste is produced as clay, and the largest spoil-heap contains a million tons of material. Some of this sand and fine aggregate is now used for concrete-making, but little or no impression can be made by this small industry on the size or number of the spoil-heaps, which from a distance look like a gigantic encampment of white tents.

[2] *Mem. Geol. Surv., Mineral Resources*, Vol. XXXI. H.M.S.O., 1929.

[3] *Mem Geol. Surv., Mineral Resources*, Vol. XIV. H.M.S.O., 1920.

[4] *Mem. Geol. Surv., Mineral Resources*, Vol. XI. H.M.S.O., 1920.

known generally as *Silica rock*, is obtained from the Millstone Grit and Lower Coal Measures of Derbyshire, Durham, and the fringes of the North and South Wales coalfields, and from the Lanarkshire coalfield.

It is fortunate that the best refractory materials—which are so much in demand by the iron and steel industry—should occur in such close proximity to some of the major centres of that industry, as in Durham, the Sheffield–Derbyshire area, South Wales, the Black Country, and central Lanarkshire.

The Commoner Minerals [1]

Broadly speaking, every acre of Britain is underlain by minerals (*i.e.* "rocks") of which *some* use could be made. But whether or no use *is* made depends partly on the geological circumstances, and is very largely a question of economics. Actual quarries and mines are situated where they are because the operations can be profitably conducted—the quality of the rock is satisfactory for the purpose for which it is intended, the physical setting and available technical aids permit extraction to be undertaken at reasonable cost, and the operations can take place in suitable geographical relationship to the market for the output, and connected thereto by appropriate means of transport. Naturally enough, therefore, in a highly developed country like Britain there will tend to be clay pits and gravel pits widely scattered over the country, serving local needs, but there will also be great concentrations of such pits in those areas where geological and economic circumstances are peculiarly favourable—as with the Oxford Clay brick-making industry of Peterborough, for example, and the gravel industry of west Middlesex; so also with the limestone quarrying of Buxton, and the chalk quarrying for cement on the Thames estuary.

Igneous Rocks. Igneous rocks are less widespread in Britain than most of the sedimentary rock types, and the occurrences are almost entirely within the Highland Zone, so that any isolated outcrops in the Lowland Zone—the Leicestershire "granites" for example—are additionally important. Igneous rocks may be divided into the very coarsely crystalline granites, which are mainly used as ornamental and monumental stones and for heavy constructional work, and the finer-grained rocks, from fine-grained granites to basalt, which are mainly quarried for road-making materials. The question of accessibility is a major factor in the quarrying of these rocks, and large areas of some of the outcrops (*e.g.* the Cheviot granite) are quite untouched. Of the ornamental and constructional stones the most noteworthy are certain of the granites of Devon and Cornwall, the

[1] S. H. Beaver, "Minerals and Planning," *Geog. Journ.*, CIV., 1944, 166–193; *idem*, "Surface Mineral Working in Relation to Planning," Town Planning Institute, 1949 (*Report of Summer School at St. Andrews*).

Shap granite, and the Aberdeen and Peterhead granites. Of the granitic rocks used for road stone those of Leicestershire (Mount Sorrel, etc.) are most utilised, with others coming from North Wales (the Lleyn), Devon, and Cornwall. Of the rocks of basaltic type the chief is the Whin Sill of Northumberland and Durham, and there are other noteworthy occurrences in the Clee Hills of Shropshire, the Rowley Hills of the Black Country, and at Penmaenmawr in North Wales. Metamorphic rocks are quarried for road stone in the Malvern Hills.

Slate. Slaty rocks occupy large areas of the Highland Zone, particularly in the Southern Uplands, the Lake District, Wales, Cornwall, Northern Ireland, and south-eastern Eire; but beds with cleavage sufficiently pronounced to render the rock fissile and capable of producing roofing slates are much more narrowly confined. By far the most important area is North Wales, where Cambrian slates are worked in enormous open quarries west of the Snowdon range (the Penrhyn–Dinorwic–Nantlle area) and Ordovician slates are mined underground at Blaenau Ffestiniog. Here there was a vast industry in the nineteenth century, to supply the colossal demand of the growing industrial towns for roofing materials; several narrow-gauge railways were built to cope with the traffic, terminating at Portmadoc, Port Dinorwic, and Port Penrhyn, where coastwise vessels loaded their cargoes. The vast quarries,[1] and even vaster spoil-heaps (for 95 per cent. of what is quarried is waste) have considerably altered the natural landscape. There were other slate-quarrying areas in North Wales also, and slates were obtained in the Coniston and Keswick areas of the Lake District and at Delabole in Cornwall. The competition in the twentieth century of clay roofing tiles has all but killed the slate industry, and a considerable legacy of derelict land is left behind.

Limestone and Chalk. Chalk is of course a form of limestone, but is generally considered as a separate mineral. There are many sources of limestone in Britain,[2] and many uses for it—building stone, road metal, smelting flux, lime-burning, cement manufacture, chemical industries, and agriculture. The Carboniferous Limestone formation is by far the most important source, and the very pure limestones which occur in parts of the Pennines (particularly the High Peak district near Buxton, the Clitheroe district, and Weardale), in North Wales, in South Wales, in the Mendips, and on the fringes of the Lake District are excavated in very large quarries. The Magnesian Limestone (Permian) yields building stone and *dolomite* at intervals along its outcrop from Sunderland to Nottingham. Dolomite is used for the basic linings of steel furnaces (cf. p. 351);

[1] The Dinorwic quarries, near Llanberis, cover 700 acres of the hillside, and the top level is 1,800 feet above the bottom level.

[2] F. J. North, *Limestones*, London, 1930, especially Chapters 4–12.

the most important localities for this mineral are Coxhoe (Co. Durham), Conisbrough (Yorks.), and Steetley (near Worksop). In the Jurassic series there are many fine building and facing stones, such as the Ancaster and Weldon stones of Lincolnshire, the Bath stone of the Cotswolds, and the famous Portland stone from the Isle of Portland. Some of the Jurassic limestones are also used for cement making, *e.g.* the Lower Lias in Warwickshire (Rugby, Harbury) and the Lincolnshire Limestone at Ketton in Rutland.

The Chalk has long been used in a small way as a source of agricultural lime, but the twentieth century has witnessed an enormous expansion of chalk quarrying in certain areas to serve the cement industry, and about three-quarters of the country's cement industry is based upon chalk. The chief area comprises the banks of the lower Thames, in Essex and Kent, where huge chalk quarries are accompanied by pits in the London Clay which yield the clay necessary for mixing with the chalk, and by cement works on the river bank, using water transport for incoming coal and exported cement. On the edge of the Chilterns near Tring, Luton, and Cambridge, the Lower Chalk is sufficiently clayey to be used alone for cement making. Other areas include the lower Medway and the Humber above Hull, both with water-front sites for the cement works.

Brick Clays.[1] There are more than 1,250 brickworks in Great Britain, and most of them are served by adjacent clay-holes. Nearly one-third of them use clay and shale from the Coal Measures (sometimes obtained as a by-product of coal mining)—partly because of the suitability of such clays, but also because the coalfields contain so many large urbanised areas where the demand for bricks is great. Nearly another one-third use the most recent clays—glacial, alluvial, brickearth, etc. The remainder mostly use Jurassic and Cretaceous clays. This simple statement, however, conceals a most important fact, namely, that over one-third of the country's brick output comes from about thirty mass-production works which use the Oxford Clay formation in the vicinity of Peterborough, Bedford, and Bletchley, in the "Great Clay Vale." The Oxford Clay yields a thick and reasonably homogeneous clay containing about 5 per cent. of carbonaceous matter, which makes for a very low fuel consumption. The clay is dug by large excavators, and the bricks are mechanically pressed into shape. The works at the new village of Stewartby, near Bedford, is the largest in the world.

Roofing tiles are also mostly made from clay. Many small brickworks also make tiles, but a large proportion of the country's output is made from the Etruria Marl formation (Upper Coal Measures) in the North Staffordshire coalfield and in the Black Country. The

[1] See *Clay Brickmaking in Great Britain*, National Brick Advisory Council, Paper VI. H.M.S.O., 1950.

same formation yields the famous engineering bricks known as "Staffordshire blues."

Sandstones and Sands. Sandstones, of varying hardness, are used for building and constructional purposes, for road metal, for paving, for grindstones, and sometimes, as already noted, for refractories. As local building material sandstone is often evident in villages and towns, but little is quarried for this purpose now, and to an increasing extent concrete slabs and tarmacadam are replacing the paving flags which used mostly to come from the mid-Pennines of Yorkshire and Lancashire. The Millstone Grit and Coal Measures have been by far the more important sources of sandstone in the past. Red Triassic sandstones are very much in evidence in churches and large buildings all over the Midlands; the Old Red Sandstone has been much used in Scotland.

Sands, from relatively less-consolidated deposits, have many uses, of which the most important are in building (mortar, concrete, etc.), metallurgical work, and glass-making. Foundry sand for metal-casting is mostly obtained from the Trias of the west and east Midlands. Glass-sand, of exceptional purity, comes especially from the Lower Greensand of Leighton Buzzard and Kings Lynn, and from a superficial deposit known as the Shirdley Hill Sands in south-west Lancashire. Sand for concreting comes almost entirely from gravel-pits.

Gravel.[1] The three major sources of gravel are (i) river-gravels, alluvial, and terrace; (ii) glacial deposits—sheets of sand and gravel deposited as glacial outwash beyond the limits of the ice-sheets, and occasional morainic accumulations and eskers; (iii) "solid" deposits, of which the chief is the Bunter Pebble Beds (Triassic) of the West Midlands (mainly north and south Staffordshire). The river gravels are commonly worked in "wet" pits, i.e. the gravel is mechanically dug or pumped from beneath the permanent water-level, so that a lake is left behind when the gravel has been extracted. The glacial gravels, more frequently occurring at higher levels, are usually worked in dry pits just like most other minerals. The deposits are very widespread and scattered, which is fortunate since the demand for sand and gravel for building, for road-making, etc., is also spread throughout the country. Gravel mostly moves by road to its destination, and relatively little goes beyond an economic margin of about 30 miles. There is some tendency to concentrate on the broader and more profitably worked gravel spreads, particularly of river gravels, which are usually cleaner and more homogeneous than the glacial gravels, and about one-third of the country's output comes from the Thames terraces of the London area, where land-use

[1] S. W. Wooldridge and S. H. Beaver, "The working of sand and gravel in Britain: a problem in land use," *Geog. Journ.*, CXV., 1950, 42–57. See also the Reports of the Advisory Committee on Sand and Gravel, H.M.S.O., 1948–1953.

Photo: S. H. Beaver

FIG. 184.—A "wet" gravel pit in the Soar valley, Leicestershire

The gravel is dug from beneath the water level by a dragline excavator. The islands in the lake are of clay or worthless gravel

problems of considerable magnitude are created owing to the high agricultural value of the terrace lands and the many competing uses for land within the Metropolitan region. But at least the "Great Wen" provides abundant waste materials for filling up the lakes which gravel extraction creates.

As already noted, the gravel industry has for some time been second only to coal-mining in respect of output tonnage. There are about a thousand gravel pits in the country, and their annual land consumption is of the order of 1,500 acres, which is about one-half of the total land area consumed annually by quarries of all kinds.

MINERAL OIL

The serious search for oilfields in this country began during the First World War under the auspices of the Geological Survey at a time when the German submarine menace made home supplies of all commodities of vital importance. Prior to this, one occurrence of natural gas had long been known. About the middle of the last century a well near the new railway line at Heathfield in Sussex tapped a small gas field and natural gas was used to light the lamps at Heathfield station for some years. Exploration during the First World War was concentrated on the Carboniferous rocks of the

Midlands of England where traces of bitumen had long been known, and in central Scotland in the area where oil shale had long been worked. Some small shows of oil were detected, but the net result was a solitary oilwell, that of Hardstoft in Derbyshire.

Prior to 1938 Hardstoft yielded a total of 2,600 tons of oil and went on yielding in decreasing quantities until 1945 when the output recorded was 50 tons. It would seem that Hardstoft was almost unique in the history of oil technology in that a dyke or sill of igneous rock cutting across an oil shale had resulted in the distillation of the oil from the shale, and the oil remained accumulated in the fissures of the surrounding Carboniferous rocks until tapped by what can only be described as an extremely lucky boring.

In the period between the wars the Government passed the Petroleum Production Act in 1934, an Act which nationalised the oil resources of the country, at that time unknown except for the Hardstoft occurrence. This first decree of nationalisation by the Government received remarkably little attention, but it permitted the Crown to encourage active exploration for oil, which was undertaken by a subsidiary of the Anglo-Iranian Oil Company.

Many trial borings were made in the south of England, the first drilled during 1936–1937 at Portsdown Hill, near Portsmouth. A showing of oil, not in commercial quantities, however, was found in the Upper Jurassic rocks before the boring ended in the Trias at 6,556 feet. Numerous borings all over the south, the midlands, and much of the north of England added greatly to our knowledge of underground geological structure and yielded three results of direct economic importance. One was the discovery in a deep bore in Eskdale in north-east Yorkshire which reached a depth of 5,040 feet, of potash salts resembling those of the famous Stassfurt deposits of Germany; and also in the same well a gas sand yielding 2½ million cubic feet per day of almost pure methane. It is intended eventually to exploit both these natural resources.

The second positive discovery was an oilfield at Eakring in Nottinghamshire. The oil occurs in an anticline in the uppermost members of the Millstone Grit series, just below where they are unconformably covered by Magnesian Limestone and later deposits. Eventually more than 400 wells were drilled in the oilfield and surrounding areas, one reaching 7,476 feet, nearly a mile and a half and the deepest boring in Britain. The oilfield was brought into production in 1939 and reached a peak production of over 80,500 tons in 1943 before a decline began.

Nearby there had been an early and accidental discovery of oil in a boring for coal at Kelham near Newark. This field, closely connected with the one at Eakring, was also developed and came into production in 1941, reaching a peak production of nearly 29,000 tons in 1943. Just to the north another small anticline at Caunton

yielded an appreciable return. The third discovery was of a small deposit of oil trapped by a fault and a covering of Boulder Clay near Formby in Lancashire.

By the end of 1946 the oilfields of Britain had yielded a total approaching half a million tons of oil, or an overall total of about 115 million gallons. Such figures seem large until they are measured against the total peacetime consumption in this country. They form about 0·3 per cent. of the total. In the post-war years 1946–1950 the output has averaged rather under 50,000 tons a year.

Oil Shale. Oil shale, unlike coal, was worthless until industrial technique had reached a high degree of development. Oil shales had long been known to occur in the Carboniferous rocks of Scotland and although they had never been worked for any purpose some of them were so rich in oil that they could easily be kindled into flame, and it was in the 1850's that James Young, using a seam near Broxburn, produced oil on a commercial scale. He was so successful that Scotland began to supply almost all the world-wide demand for mineral lubricant and lighting oils, as well as for paraffin wax. It was not until 1859 that petroleum was discovered in commercial quantities in Pennsylvania and American competition appeared. The richer shales of Scotland yielded as much as 80 gallons of oil per ton. When these were exhausted yields from poorer shales dropped to about 20 gallons per ton, but the by-products proved more valuable than both the oil and wax obtained. In particular large quantities of ammonia were obtained which combined with sulphuric acid made on the spot to form ammonium sulphate, which is a valuable manure. For the greater part of a century the production of shale oil from Scotland has gone on, and the countryside of West Lothian is littered with gaunt red spoil heaps of burnt shale. In 1931 there were still 2,640 men employed in Scottish oil shale mines, and the output of crude oil in the nineteen-thirties was about 125,000 tons a year.[1] Wartime needs during the Second World War stimulated production, which reached 149,000 tons in 1941. Since the end of the war the average has been about 110,000 tons, obtained from about 1,400,000 tons of oil shale. The refinery is at Pumpherston (see p. 567).

Reference is made elsewhere (see pp. 566–7) to the modern industry of the hydrogenation of coal to produce oil and the oil refining industry concentrated around the British coasts.

REFERENCES

The Geological Survey's *Special Reports on the Mineral Resources of Great Britain*, now numbering 35 volumes, published by H.M.S.O. at intervals since 1916, cover all the metallic ores and most of the "rarer" non-metallic minerals. There is no comparable treatment of the commoner minerals; for a general survey see S. H. Beaver, "Minerals and Planning," *Geog. Journ.*, CIV, 1944, 166–198.

[1] See *Scottish Oil-Shale Industry*, Command 2538, H.M.S.O., 1925.

CHAPTER XVI

IRON AND STEEL[1]

THE origin of the British iron industry is lost in obscurity. The five hundred years before the Christian era, however, are known as the Iron Age, and in all probability the Celtic inhabitants of Britain were fairly expert in the working of the metal; the finding of Celtic pottery in association with iron slags in the Furness[2] district and near Northampton[3] is evidence of at least two localities in which the actual smelting was performed. That the Romans worked the iron ores of our islands is also quite certain. Sites of furnaces and heaps of slag lying near accumulations of Roman coins and pottery have been identified in Furness, in the Forest of Dean, in the Weald, in the Mendips, in Northumberland and Durham, in Northamptonshire, and in South Wales.[4] The earlier furnaces were usually situated in exposed places, where the wind would create a natural blast; later, sites were chosen along streams where a small water-wheel could be used to work the primitive bellows. After the Roman occupation there are few records and, apart from a few scattered notices in the Domesday Survey,[5] where "ferraria" (iron-works) are occasionally mentioned, we have no positive information until the twelfth century.

The two most important medieval centres of the iron industry were the Forest of Dean and the Weald of Sussex and Kent.

(1) *The Forest of Dean.*—This was for long the chief area in the country for iron smelting.[6] As early as 1282 there were sixty forges in the forest using the local ore, and the industry continued to flourish for many centuries. In the seventeenth century the area was importing richer ore from Lancashire to supplement the local supplies and was sending iron to the Birmingham area for working up into implements and weapons.

[1] By S. H Beaver.

[2] G. M. Tweddell, *Furness Past and Present.* 1876.

[3] *Victoria County History*, Northamptonshire, I, 151.

[4] Kendall, *Iron Ores of Great Britain and Ireland.* Crosby, Lockwood. 1892. Chapter II. More detailed references will be found in the volumes of the *Victoria County History*, *e.g.* Cumberland, II, 385–406; Durham, II, 278–293; Yorkshire II, 341–351; Lancashire, II, 360–364; Derbyshire, II, 356–362; Gloucestershire, II, 216–233; Worcestershire, II, 267–271.

[5] *E.g.* Gloucestershire, in the Forest of Dean, and at Pucklechurch; Northamptonshire, at Gretton and Corby; Yorkshire (East Riding), at Hessle.

[6] See H. G. Nicholls, *Iron Making in the Olden Times.* 1866.

(2) *The Weald of Sussex and Kent.*—In the sixteenth and seventeenth centuries this area was even greater than the Forest of Dean in the importance of its iron industry. The first cast-iron guns were made at Buxted in 1543, and a large proportion of the British ordnance was subsequently made in the Weald. In 1574 there were no less than 32 smelting furnaces and 38 forges in Sussex, besides numerous others in Kent.[1]

In addition we have definite records of iron making in Northumberland and Durham from the thirteenth century onwards, in Northamptonshire and Lincolnshire in the twelfth and thirteenth centuries, in the West Riding of Yorkshire from the twelfth century, and in Rosedale (North Riding) in the fourteenth century, in Cumberland and in Derbyshire from the twelfth century, in the Furness district from the thirteenth century, and in South Wales from the fourteenth century, together with evidence of the existence and working of iron ore in certain other localities. In fact, during the medieval period, the iron industry in Britain was fairly widespread, owing to the abundance of iron ore near the surface in many parts of the country, and the ample timber supplies which could nearly always be found in the vicinity of the ore deposits. So great was the amount of charcoal necessary, however, that the forests were being rapidly depleted,[2] and in the reign of Queen Elizabeth stringent measures were passed to prevent the reckless destruction of our timber supply at a time when every log was valuable for building ships of war. Only those areas, then, which were especially favoured by extensive forests, like the Weald and the Forest of Dean, were able to maintain their industry on a large scale; for, however rich a deposit might be, overland movement of the ore was impracticable except for short distances when pack horses were the only means of transport available. The Cumberland and Lancashire region, lacking extensive timber resources, but having a seaboard situation, continued to extract ore for export by sea to the Forest of Dean and South Wales and later to Ayrshire and the Clyde.

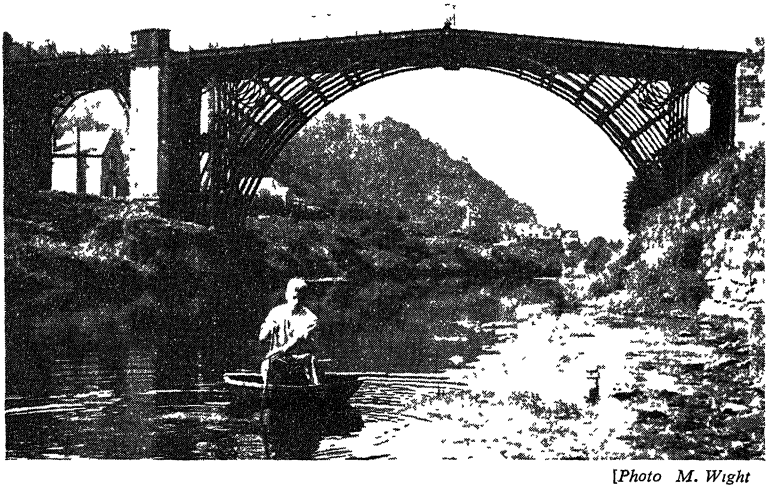
This distribution of the industry began to suffer a radical change in the eighteenth century owing to the substitution of coal for charcoal in the smelting process. Dud Dudley, a Staffordshire ironmaster, had patented a process of smelting iron with "pit-cole" and "sea-cole" as early as 1621, but neither his nor other suggested methods were successful, and owing to the failing timber supply the British iron industry suffered a steady decline for over a

[1] See W. Topley, *Geology of the Weald*, 1873 (H.M.S.O.), also E. Straker, *Wealden Iron*, 1931 (George Bell); and M. Delany, *The Historical Geography of the Wealden Iron Industry*. 1921 (Benn).

[2] It is probable that an acre of woodland yielded only sufficient charcoal to make three tons of iron, and as a single furnace in the sixteenth century could make 20 tons a week it is obvious that the destruction of the forests must have been very rapid.

century.[1] By 1740, in fact, we were importing mainly from Sweden and Russia nearly twice as much iron as was made at home.

The real beginning of the modern era of iron making came with the introduction, in the 1730's, by Abraham Darby, of the method of coking coal for use in the blast furnace. Darby had probably smelted iron with coke as early as 1709, but such a revolutionary innovation as this naturally required many years of experimenting for its perfection, since so little was known of the properties of the coal and the iron ore and of the chemical reactions that went on inside the furnace. Moreover, not all coals were found to be suitable for coking,[2] and the quality of the pig iron could not always be relied



[*Photo M. Wight*

FIG. 185.—The first iron bridge, constructed across the River Severn in 1779

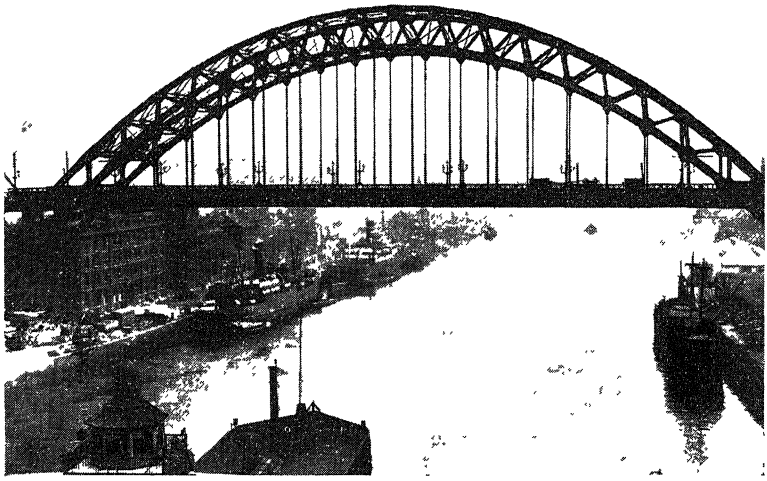
The bridge is now scheduled as an ancient monument and closed to all traffic. The town is known as Ironbridge. Coracles of ancient type such as the one shown are still occasionally used

upon. It was not until about 1760 then that the erection of new and larger furnaces adapted for using coal and coke inaugurated a period of development and expansion in the iron industry. This development coincided with, and was to a large extent aided by, the perfection of the steam engine, which could be used for pumping water out of flooded coal mines and for creating the more powerful blast which the use of coke in the furnace demanded. Smeaton built the first steam engine for producing blast in 1760, but it was left to James Watt to commence the construction of efficient engines on a com-

[1] T. S. Ashton, *Iron and Steel in the Industrial Revolution*, 2nd Edn., 1951, p. 10. This book is indispensable for a study of the iron industry in the eighteenth century.

[2] The coal used by Darby was the "clod," which proved peculiarly suited to the process of carbonisation in large lumps in open heaps—cf. p. 323.

mercial scale about 1775, and a few years later to adapt his engines to rotative motion. The consequences were profound. The steam engine needed a large amount of iron in its construction, and an increased iron production in turn necessitated the provision of more and larger engines, not only for blowing the furnaces, but also for pumping and working the winding machinery of the coal mines, which were stimulated by the demand for more coal for smelting. The increased capacity for iron production was also followed by a rapid increase in the number and variety of the uses to which the



[*Photo Fox Photos Ltd.*

FIG. 186.—One of the latest steel bridges, constructed across the River Tyne at Newcastle

This bridge is similar in design to the Sydney Harbour Bridge, Australia, constructed by the same firm

metal could be put. The first cast-iron bridge was built at Iron-bridge in 1779, and during the next few decades all kinds of machinery, especially textile machinery, were introduced to replace contrivances formerly made of wood or the less common metals, copper and brass.

In 1784 Henry Cort perfected the puddling furnace for making malleable or wrought iron, using coke as fuel. He also introduced the use of rollers in place of hammers in drawing out the iron into bars. These processes provided a further stimulus for the iron industry by enabling much larger outputs to be obtained in very much less time than formerly, and they helped to strengthen a

movement which had been going on for twenty years, namely the increasing concentration of the ironworks on the coalfields. Progress was not rapid—in 1788 nearly half the furnaces in Britain were still using charcoal—but slowly and surely the pull of those areas which were favoured with abundant iron ore in the same measures as the coal seams was beginning to assert itself. By 1806 only 11

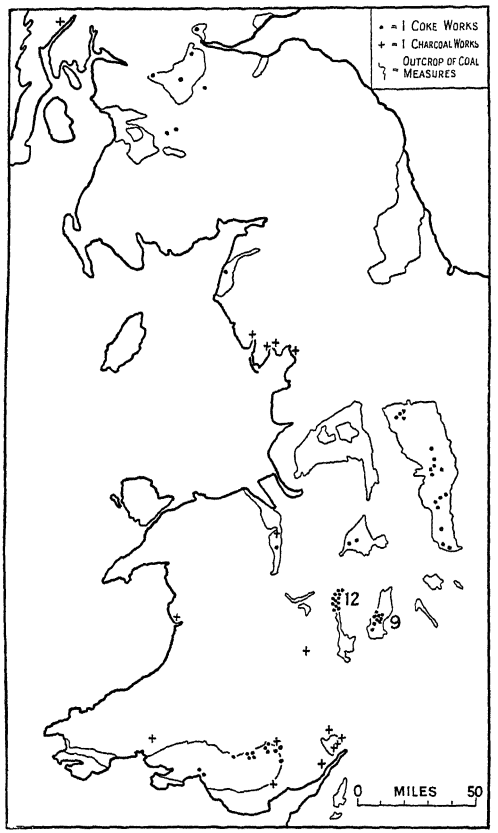


FIG. 187.—Blast furnaces in 1796

Exposed coalfields outlined. The last of the Wealden furnaces, at Ashburnham, is not shown on this map. Note the absence of furnaces in south Lancashire and north-eastern England

charcoal furnaces remained out of the 300 or so that existed 150 years earlier, and the clustering of the ironworks round the coalfields of South Wales, South Staffs, Salop, and Derby was very marked. The coalfields of Northumberland and Durham and South Lancashire, however, being almost devoid of Coal Measure ironstones (see Fig. 192) and lacking coals which could be coked by the methods then available, failed to develop extensive iron industries at this time.

The iron industry also received a considerable fillip during this period from the waging of wars, which necessitated large supplies of iron weapons and ammunition. The American War of Independence occupied the years 1776–1780, and between 1793 and 1815 wars were almost continuous on the Continent. These wars not only stimulated our iron industry but, by ruining the greater part of Europe, placed Britain in a very strong commercial position.[1]

The first half of the nineteenth century was a period of gradual expansion and of improved technique in the iron industry.[2] Two events are important. In 1828, Neilson, a Glasgow gasworks foreman, suggested the use of hot, instead of cold, air in blowing the furnace. This process, which reduced the fuel consumption considerably, gave a remarkable fillip to the industry in Scotland, and was later taken up in England.[3] Then in the 'forties came the "railway mania," which created an enormous demand for rails and locomotives. The first successful locomotive had been built in 1812 by Blenkinsop, and the Stockton and Darlington Railway was opened in 1825; but the years 1845–1847 marked the great boom in railway development.

Throughout the period since the introduction of coke fuel the ores of iron used in Britain had been of the clayband and blackband[4] types occurring in the Carboniferous rocks, together with smaller amounts of hæmatite from Cumberland and Furness. In 1851 the pig-iron production of Britain stood at the level of about 2½ million tons (which was half the world's supply) of which the greater part (*c.* 2·1 million tons) came from three areas, Scotland, South Wales, and South Staffordshire. It is not surprising, therefore, to find that the Coal Measure ores, especially in the Midlands, where working had been going on continuously for over a century, were beginning to show signs of a decreasing yield due not so much to actual exhaustion as to the increased cost and difficulty of working the seams of nodules at a considerable depth. At this juncture, however, an entirely new source of ore supply was discovered[5] in the belt of Jurassic scarplands which stretches across England from the Cleveland Hills to the Dorset coast. These ores, first worked in North Yorkshire about 1850, and in Northamptonshire a year or

[1] L. C. Knowles, *Industrial and Commercial Revolutions of the 19th Century*, 1927, p. 102.

[2] 1816, Rogers' improved puddling furnace; 1842, Nasmyth's steam hammer; 1845, first attempt to utilise waste blast-furnace gases for heating blast and raising steam.

[3] See, with reference to this and to the matter of the preceding paragraphs, H. Scrivenor, *History of the Iron Trade*, 2nd edition, 1854.

[4] Blackband was not discovered till 1801, and not extensively employed until after the introduction of the hot-blast. See D. Mushet, *Papers on Iron and Steel* (1840).

[5] Or rather rediscovered, for, as we have seen, Roman and medieval workings are known to have existed in Northamptonshire, Lincolnshire, and North Yorkshire.

two later, have had far-reaching effects upon the development of the British iron and steel industry, and their importance is difficult to over-estimate. The commencement of iron smelting in Cleveland and Northamptonshire marked the beginning of a decline in that great attraction which had been exercised by the coalfields ever since the introduction of coal as a fuel in the process of smelting. When every ton of pig-iron needed eight tons of coal to smelt it the setting up of furnaces away from the coalfields was obviously not an economic proposition. But with coal consumption reduced to two or three tons and the use of the Jurassic ores entailing an ore consumption of about the same amount, it became possible for the costs of coal and ore transport to be reduced almost to level terms, and at once the pull of the coalfields began to decrease in strength. The seaboard situation of Cleveland, together with the nearness of the Durham coalfield, now available as a source of coke through the development of the beehive coke-oven, sent this area forging far ahead of the inland Northamptonshire, where coking coal was at least 60 miles away.

The second half of the nineteenth century witnessed remarkable progress in the heavy metallurgical industry of Britain, a progress which was intimately bound up with the substitution of steel for wrought-iron. Huntsman's crucible furnace, invented in 1742, had for over a century been the only efficient means of producing steel, and this was a very costly process. In 1855 only about 50,000 tons of steel were produced in Britain at a cost of £75 per ton. In 1856 Bessemer introduced his "converter," which, making use of the heat generated by blowing a blast of air through a ladle of molten pig-iron, without the employment of the large amount of fuel consumed in the crucible method, could produce much larger quantities of good steel in a much shorter time (about 20 minutes only) at much less expense. Indeed, by 1864 the price of a ton of open-hearth steel rails had been reduced to £17 10*s*.[1] Almost on the heels of Bessemer came William Siemens, who in 1861 patented the "open-hearth" type of regenerative gas-fired furnace for steel making. As with most revolutionary inventions, however, it took many years for the new steel processes to become firmly set, and nearly 30 years elapsed after Bessemer's invention before steel finally succeeded in supplanting wrought-iron. Until the early 'eighties, in fact, the enormous demand for iron rails and iron ships was accompanied by a corresponding rapid increase in the size of the puddling industry and the number of puddling furnaces rose from 3,462 in 1860 to 7,575 in 1875.[2] Moreover, except in certain cases, the steel industry was hampered by the necessity, in both the converter and open-hearth processes (which employed acid, or silica, furnace linings), for fairly

[1] Lowthian Bell, *The Iron Trade of the United Kingdom*, 1886, p. 20.
[2] Lowthian Bell, *op. cit.*, p. 20.

pure, non-phosphoric ores, such as occur in Britain only in Cumberland and North Lancashire. The bulk of British ores, including the Jurassic ironstones, were useless for steel making, and thus we find a new feature introduced into the British iron and steel industry, namely, the import of large quantities of rich, non-phosphoric ores from Northern Spain into those steel-making areas such as Cleveland and South Wales, which were either on the coast or had easy access thereto. In 1869 scarcely 1 per cent. of the ore used in Britain was imported. In 1882 this figure had risen to 18 per cent.

The invention in 1879 by Messrs. Thomas and Gilchrist of the "basic process" (i.e. lining the steel furnace with a basic material such as dolomite, in order to get rid of the phosphoric impurities) might have been expected to change this state of affairs, since it permitted the use, for steel working, of the abundant phosphoric ores in the Jurassic rocks of Cleveland and the south-east Midlands. But the basic process, needing special furnace linings and entailing the payment of high royalty charges, was then more costly than the acid process; and so cheap were the rich foreign ores that it was actually less expensive, at Middlesbrough, to convert rich Bilbao ore into steel rails by the acid process than to manufacture iron rails without conversion into steel from the lean phosphoric ore of the Cleveland Hills only a few miles away.[1]

Whether acid or basic, however, the production of steel rapidly increased in the last quarter of the nineteenth century, and steel began to be used for almost every purpose to which puddled iron had previously been applied—of which the most important were for rails, ships, and in constructional engineering.[2] But whilst British production of iron and steel continued to expand, our position relative to the rest of the world exhibited a slow decline. Between 1850 and 1870 Britain was producing every year about one-half of the world's output of pig-iron. The expansion of the industry in the United States, however, and the great development of basic steel in France and Germany, considerably reduced Britain's supremacy, and by the early 'nineties the United States and Continental Europe had each exceeded the British output, and the home country produced less than one-third of the world's pig-iron. By 1913 we were producing

[1] Lowthian Bell, *op. cit*, p. 17.

[2] *Note on Iron and Steel*—Pig-iron—or cast-iron—from the blast furnace is not pure. It contains carbon, and, if made from certain classes of ore, may contain sulphur and phosphorus; all these three elements are injurious and render the iron brittle. The carbon may be eliminated by stirring the molten iron in a puddling furnace; as the carbon disappears the liquid becomes pasty and is removed in lumps to be hammered or rolled. This is wrought-iron, very tenacious but not hard enough for many purposes. The acid process of steel making so effectively removes the carbon that a small proportion has to be replaced by the addition of ferro-manganese or Spiegeleisen, which contains some carbon. Steel may contain 0·3 to 2·2 per cent. of carbon, it becomes exceedingly hard when cooled suddenly, and it is more flexible and elastic than wrought-iron, although not so durable when exposed to the weather. (Cf. Diagram on p. 355.)

only one-eighth of the world's total (10 million tons out of 78 million tons), and the United States and Germany had both passed our production by a considerable margin.[1] The tale of the steel industry is similar. Before the introduction of the basic process Britain was

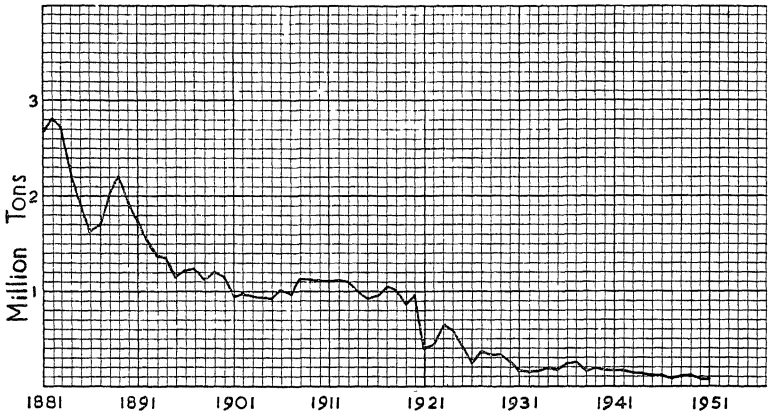


FIG. 188.—Production of wrought-iron

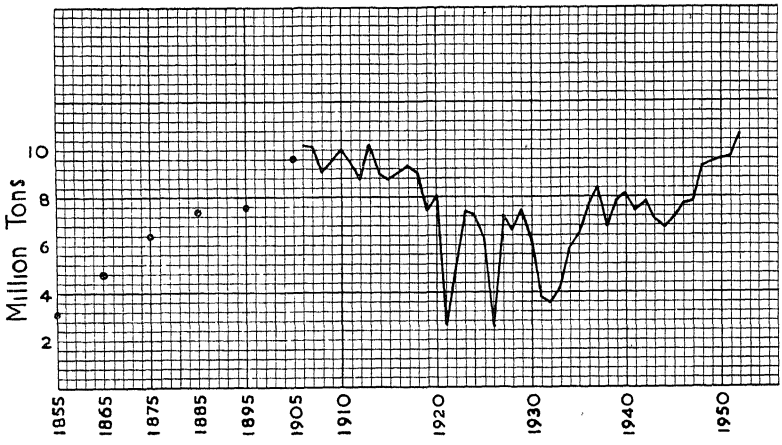


FIG. 189.—Production of pig-iron

easily first, but thereafter Germany (using the basic process with Lorraine ores) and the United States (using the acid process with Lake Superior ores) began to develop rapidly, and by 1913 Britain was producing little more than one-tenth of the total world output[2] (7·7 million tons out of 75 million tons).

[1] Germany, 16·76 million tons; United States, 30 97 million tons.
[2] See tables on pp. 113–114 of *Survey of Metal Industries*. H.M.S.O., 1928.

The period from the commencement of the supremacy of steel until the First World War is characterised first by the great absolute expansion of the steel industry both at home and abroad, with the relative decline of Britain amongst the other great steel-producing nations;[1] and secondly by vast improvements in the technique of smelting and steel production, entailing a more efficient use of all apparatus and raw materials employed, and especially a considerable reduction in fuel costs. A third feature of note is the concentration on the open-hearth process at the expense of the Bessemer converter. The open-hearth furnace, although taking a longer time (some 6–12 hours) to convert pig-iron into steel, permits of greater control of its

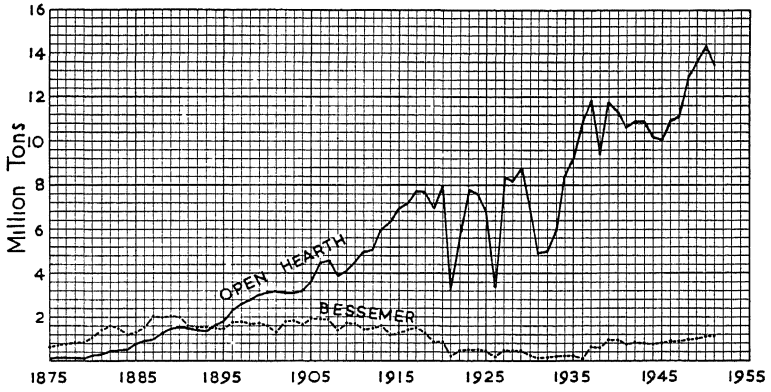


FIG. 190.—Production of steel

contents and so the production of more carefully graded and uniform steel and, moreover, it allows the employment of scrap, a very important economic consideration.[2]

The war of 1914–1918 found the British steel industry ill-adapted for prompt adjustment to the tasks which had to be performed as a result of the phenomenal demand for steel of all grades. The war-time necessity of relying more on home iron ores and less on imports led to a considerable reorganisation of certain sections of the industry, with a material increase in the output of basic steel.

The recurrent economic crises of the period 1920–1933, the boom of 1920, the slump of 1921, the general strike of 1926, the boom of

[1] See, on this and other matters, T. H. Burnham and G. O. Hoskins, *Iron and Steel in Britain, 1870–1930*, London, Allen & Unwin, 1943.

[2] On an average some 60 per cent. of the raw material of the British steel industry consists of scrap, but in individual furnaces the percentage may rise to over 80. Other important considerations are the low melting losses compared with the Bessemer converter (5 per cent. cf. 15–20 per cent), and the fact that gas for firing is often readily available from the coke ovens and blast furnaces of "integrated" works.

1929 and the disastrous depression of 1931–1933 not only took their toll of the less efficient sections of the industry (cf. the figures given under Fig. 198) but also provided the stimulus for a great amount of reconstruction and reorganisation which took place during the later 1930's and which rendered the British iron and steel industry much more capable, in 1939, of coping with a new war than it had been in 1914. Two new works of major importance, on the site of older works, came into existence—at Corby and at Ebbw Vale—and in almost every major producing district extensive reconstruction schemes were carried out, with an increasing proportion of the total output of iron and steel coming from a decreasing number of large, integrated works (i.e. works in which all the processes from coking

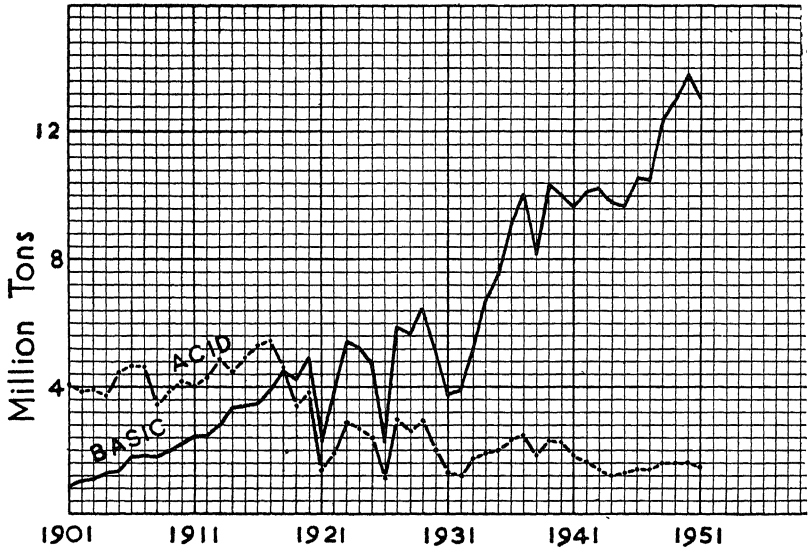


FIG. 191.—Recent production of acid and basic steels compared

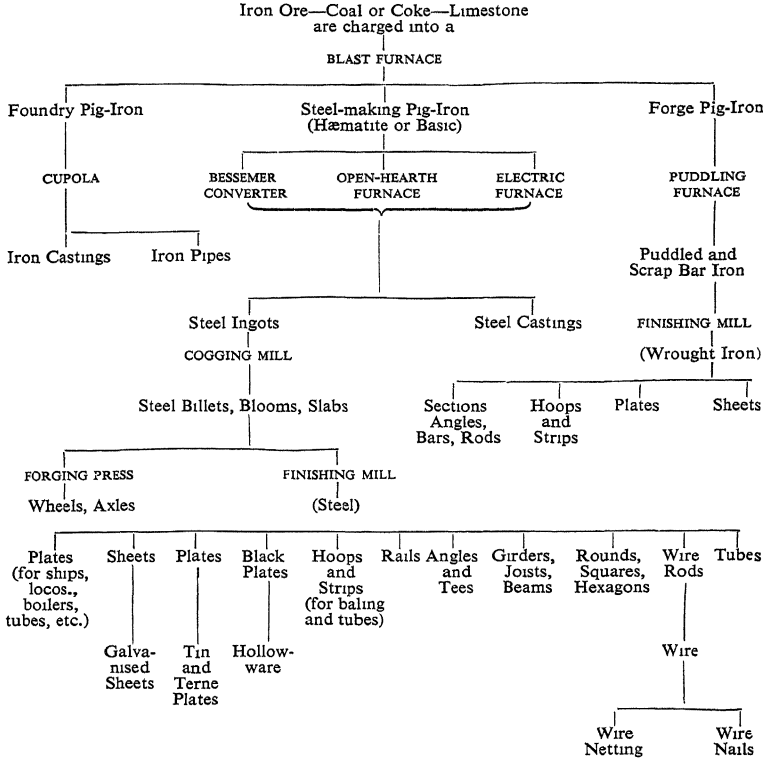
and smelting to the rolling of finished steel products are carried out on one site).

The Second World War, like the First, resulted in a somewhat changed pattern of production, with once again increasing emphasis on the use of home-produced Jurassic ironstones, and in addition with a greatly increased proportion of alloy steel (produced especially in Sheffield).[1] The post-war period, however, has not repeated the disastrous history of the 'twenties. The industry has gone from strength to strength; there have been no closures, and two major

[1] The story of British iron and steel during the war is told statistically in the British Iron and Steel Federation's volume covering the years 1939–1944. See also *Iron and Coal Trades Review*, Nov. 2, 1945, pp. 667–670, and March 29, 1946, p. 578.

new projects—at Margam in South Wales, and at Shotton, on Deeside—were nearing completion in 1953.[1]

The table given below (adapted, with emendations, from "Survey of Metal Industries," p. 2) may assist the reader in his comprehension of the various processes and products of the iron and steel industry.[2]



THE PRESENT CONDITIONS OF THE INDUSTRY

There are three major factors affecting the localisation of an iron and steel industry—the supply of ore, the supply of fuel, and the market for the produce.[3] One or more of these must be present

[1] See special issue of *Iron and Coal Trades Review* entitled "Steel and Britain's Future," Vol. CLIX, No. 4255A, September 30, 1949.

[2] See J. Dearden, *Iron and Steel To-day* (Oxford, 1939), for an excellent popular account of the principles and processes of the industry.

[3] Whilst a supply of limestone is normally essential to the industry (about 5 cwts. of limestone flux are used for each ton of pig-iron), this raw material is never a localising factor, since limestones are so readily available in most districts where either iron ore or coal are found; *e g.* Coal Measure ironstones were seldom far from thick Carboniferous or Magnesian Limestone deposits, and the Jurassic ironstones occur in a series, the principal members of which are frequently limestones of greater or less purity.

in order to give rise to such an industry. The earliest British iron industries in the Forest of Dean and the Weald were situated where ores of iron were found in close proximity to an assured charcoal supply from the forests. Similarly, the first iron industry based on coal as a fuel became localised in Staffordshire and Salop, where both coal and iron were found in the same series of rocks. The industries of Cleveland and of the Furness district of Lancashire, however, were localised upon ore-producing regions, with the near-by Durham coke and the coastal situation for the export of the produce as other favourable factors. Modern transport facilities may render possible the rise of an industry in an area devoid of both coal and iron ore—as, for example, the Ford iron works at Dagenham, on Thames-side, obtaining foreign ore and Durham coal by sea, and having its own assured market in the adjacent motor works.

Raw Materials.—In order to examine the British iron and steel industry from the point of view of geographical control of development, we must first consider the raw material supplies.

Fuel.—Coal is of course the major item, since even despite the enormous advances in fuel efficiency which have been made during the last 25 years, it still takes nearly two tons of coal to produce a ton of finished steel, and the total coal consumption is of the order of 25–30 million tons.[1] A large proportion of the coal is of course coked before use. The distribution of coking coals has already been briefly described (p. 323), and it is apparent that the actual location of coking coal resources has but slight present influence on the location of iron and steel works. There is certainly no clustering of blast furnaces in south Durham, in south Yorkshire, or in eastern South Wales, and of about 40 smelting works in the country, only about half a dozen lie in close proximity to their sources of coking coal. The transport of coking coal or coke is thus a major item in the cost of production, particularly for the works situated on the Jurassic ore-fields.

In recent years, owing to the coal shortage, there has been a tendency to employ *oil fuel* instead of producer-gas in the firing of open-hearth steel furnaces. South Wales, with the large Llandarcy refinery in the middle of the steel-making area, has gone furthest in this direction, but Middlesbrough and Sheffield have also converted many furnaces to oil firing. In 1952, 636,000 tons of fuel oil were used for this purpose, one-third of it in South Wales.

Iron Ore.—The ores of iron that occur in Britain may be grouped into four broad divisions. (See table on p. 366.)

1. *Hæmatite* (Fe_2O_3), including "kidney ore." This occurs in

[1] In 1949 the figure was 37·2 cwts. of coal per ton of finished steel, compared with 62·9 cwts. in 1924.

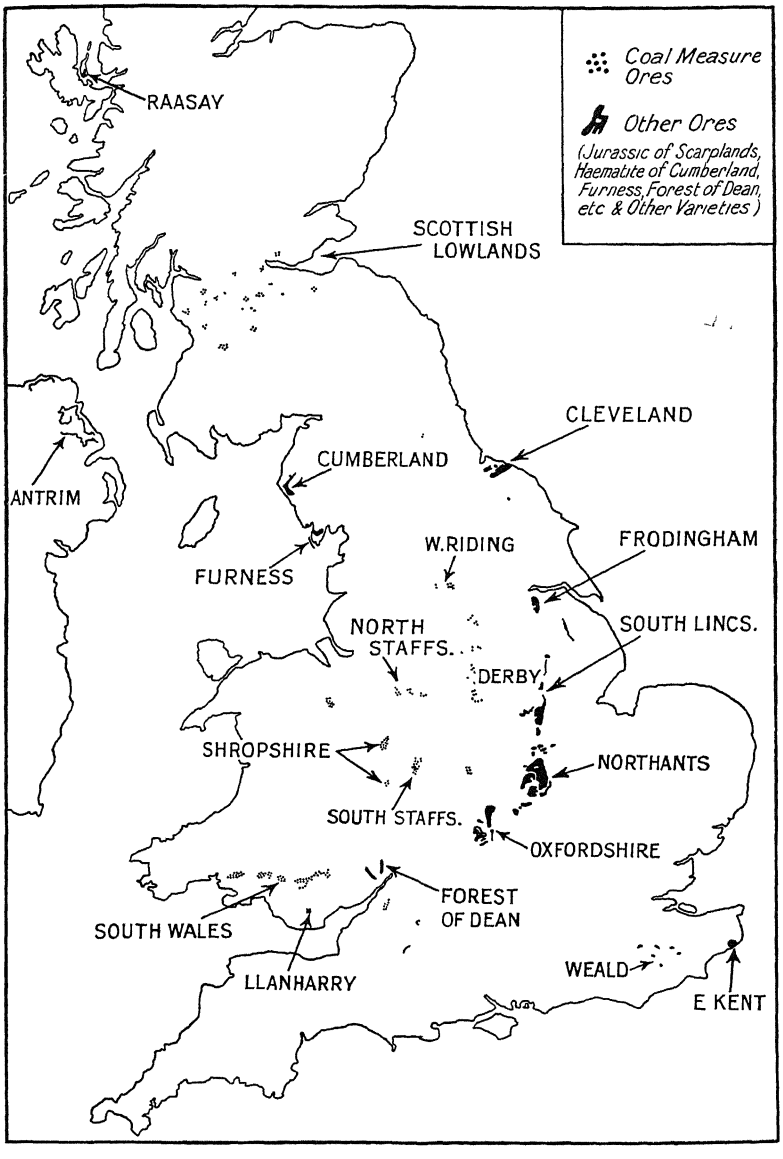


FIG. 192.—The iron ores of Britain

The only ones of present importance are the Jurassic ores of Cleveland, Frodingham, South Lincs, Northants and Oxfordshire, with the Hæmatites of Cumberland and Llanharry

Cumberland and North-west Lancashire[1] in various irregular deposits in the Carboniferous Limestone which wraps round the western and southern sides of the Lake District dome. The iron is generally assumed to have been derived by solution from the red Triassic beds which formerly covered the area, and subsequent concentration in cavities in the jointed limestone—the concentration being frequently guided by faults which brought together beds of contrasted texture.

Two separate areas are important for the production of this type of ore, and the mode of occurrence in each of these is rather different.

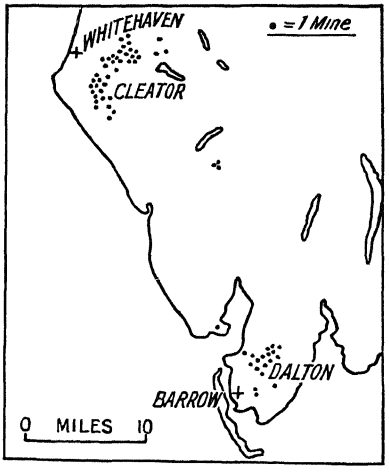


FIG. 193.—Map showing the iron mines of Cumberland and Furness in 1882

In West Cumberland, in the neighbourhood of Cleator, Egremont, and Beckermet occur numerous irregular masses of ore, sometimes disposed more or less vertically up against faults, sometimes more or less interbedded with the limestone and the sandstone and the shales which accompany it, and in other cases showing no form or structure at all. Farther south, extending on either side of the Duddon estuary from south-west Cumberland into the Furness district are a number of dish-like deposits, practically solid masses of ore occupying great hollows in the limestone. The largest of these, the famous Hodbarrow deposit, near Millom, contained originally over 8 million cubic yards of almost solid ore. In both areas the deposits are within a few hundred feet of the surface, but they are covered by thick deposits of glacial drift, which conceals the "solid" geology and increases the difficulty of locating and working the ores.

The two areas were formerly of equal importance as ore raisers, but the greater ease of working the Furness deposits has led to their extinction more rapidly than is the case with the irregular veins and masses of western Cumberland, and whereas in the early 'eighties (the period of greatest production) each area was producing about 1½ million tons per annum (see Fig. 193), the Furness area has now

[1] *Mem. Geol. Survey*, Special Reports on Mineral Resources. Vol. VIII. *Hæmatites of West Cumberland, Lancashire, and the Lake District*, 2nd edition, 1924. See also T. H. Bainbridge, "Iron Ore Mining in Cumbria," *Geography*, XIX, 1934, 274–287. Also *Geology of the Iron-Ore field of South Cumberland and Furness*, Geol. Surv. Wartime Pamphlet No. 16, 1941.

ceased to produce, whilst Cumberland has an output of only ⅓ million tons (see table on p. 366). The chief mining centres at the present time are Egremont, Beckermet, and Millom (Hodbarrow). This hæmatite is the richest ore produced in Britain, having an iron content of between 50 and 55 per cent. It is also important as being non-phosphoric.

The modern development of these ores dates from about 1825, and a great fillip was given to their extraction and export by the completion of the Furness Railway in 1846, and of the Whitehaven, Cleator, and Egremont line in 1857;[1] whilst the completion of the Stainmore Pass line across the Pennines in 1861 opened up a new route to the Durham coalfield and Middlesbrough.

2. *The Bedded Ores occurring in the Coal Measures.*[2]—These ores are of great historical interest since they were the foundation upon which British supremacy in the iron industry was built up during the hundred years 1750 to 1850. At the end of this period they still accounted for nine-tenths of the entire British output of ore, and production continued to increase in certain areas until the 'seventies. Since then, however, the output has rapidly declined both relatively and absolutely, and at the present time is virtually nil. There were two distinct varieties of ore found in the Coal Measures, "clayband" and "blackband." Clayband ironstone consists of carbonate of iron mechanically mingled with earthy matter. It usually takes the form of thin seams, either continuous or nodular, varying from a few inches to several feet in thickness, interbedded with shales or less frequently with sandstones. It is noteworthy that the clayband ores are not evenly distributed throughout the Coal Measures, either stratigraphically or in area. The areas over which they were formerly of greatest importance are South Staffordshire, Shropshire, South Wales, Derbyshire, the West Riding of Yorkshire, and the Scottish Lowlands.[3] The blackband ores are carbonaceous ironstones, i.e. they contain coaly matter sufficient for calcining the ore without the addition of coal. They occur in even closer association with coal than the claybands. They are usually found on the top of coal seams and in Scotland some blackbands are actually found to pass laterally into coal. On the other hand, however, they usually occur in thinner seams than the claybands. Their value as ores of iron was not realised until 1801, and it was some time before they were extensively used in the iron industry. The only two coalfield

[1] In the late 'fifties close on 300,000 tons of ore were being exported annually —mostly to South Wales.

[2] *Mem. Geol. Surv.* Mineral Resources. Vol. XIII, *Pre-Carboniferous and Carboniferous bedded Ores of England and Wales*, 1920; also Vol. XI, *Iron Ores of Scotland*, 1920.

[3] It should be noted that iron ores, as well as coal, occur in the "Carboniferous Limestone" and "Millstone Grit" formations of Scotland, in addition to their development in the true Coal Measures. See chapter on Coal (p. 318).

areas in which they were discovered to be developed in quantity were North Staffordshire and Scotland. In Scotland they were especially valuable since they showed such an adaptability to the use of the hot blast, a far greater reduction in fuel consumption being obtained when using blackband ores and the Scottish "splint" coal than with any other combination of ore and fuel.[1] In contrast with the hæmatite, the clayband and blackband ores are lean, containing only about 30 per cent. of metallic iron.

The decline in the output of Coal Measure ironstone has been due to two main causes. In the first place there is the actual exhaustion of many of the best seams, especially in those areas like Shropshire and South Staffordshire, which were earliest worked. But the ores are by no means wholly exhausted. According to an estimate made in 1922 there were "actual" reserves of over 1,000 million tons, and a further "probable" reserve of 1,200 million tons. The second reason is thus the increasing difficulty and cost of working such thin seams of lean ore at depth (for an enormous amount of "waste" material has to be removed and brought to the surface before the bands and nodules of ore can be extracted). This cost has been rendered prohibitive by the cheapness with which equally good Jurassic ores, quarried or mined in thick bands at small depth, can be obtained[2]. This huge reserve, then, will never be mined under present economic conditions, and in consequence the Coal Measure ores can no longer be said to exert any influence whatsoever over the distribution of the iron and steel industry.

3. *The Bedded Ores of the Jurassic Rocks.*[3]—Although certain of these ores, as in Northamptonshire and Lincolnshire, were worked in Roman and medieval times, their value as ores of iron seems to have been completely forgotten for several centuries,[4] and they were hailed as new discoveries about 1850. Since that date they have steadily increased in importance, until at the present time their output represents over 96 per cent. of the total ore raised in the British Isles. The ores occur at several different horizons in the Jurassic sequence. Several characteristics are common to them all and serve to distinguish them in a very marked way from the ores which we have previously considered. They are all lean ores, varying in their iron content from 20 to about 33 per cent.; they all occur in thick beds, generally about 10 feet thick, but ranging from a foot or two to over 30 feet, and in common with the whole Jurassic series they are tilted

[1] Owing to the amount of carbonaceous matter which they contain, the blackband ores are self-calcining and not far from being self-smelting.

[2] The average selling price of Coal Measure ironstone between 1925 and 1931 was just over 13*s.* per ton; the figure for the equally rich Northamptonshire stone was little more than 3*s.*

[3] *Mem. Geol. Surv. The Northampton Sand Ironstone: stratigraphy, structure and reserves.* H.M.S.O., 1951; *The Liassic Ironstones.* H.M.S.O., 1952.

[4] One John Morton, writing in 1712, actually denies the existence of iron ore in Northamptonshire. (*Natural History of Northamptonshire*, p. 549.)

gently to the east or south-east without being greatly disturbed by folding or faulting. Furthermore, they are all either quite close to the surface so that they can be quarried, or are easily accessible by shallow mining. In all of them the iron is in the chemical form of chamosite (a silicate of iron) or siderite (carbonate of iron), and is an original constituent of the rock, though in most cases subsequent enrichment and oxidation have occurred through the action of atmospheric waters. It is worthy of note that the "minette" ores of Lorraine are of precisely the same character and occur on almost the same stratigraphical horizon as the Northampton Sands ores. Four important deposits may be distinguished.

(*a*) In north Lincolnshire, in the neighbourhood of Frodingham and Scunthorpe, certain beds in the Lower Lias formation are ferruginous. This is the thickest of the Jurassic ironstones, between 20 and 30 feet being worked, and all the work is opencast, for, although the thickness of overburden may amount to 45 feet, it consists of soft clays and shales which can be removed mechanically. The ore is, however, very lean, averaging only 20–22 per cent. of iron; moreover, it contains up to 25 per cent. of lime and an appreciable quantity of manganese—both qualities which influence the technique of its utilisation. The Frodingham ore was first worked in 1859; the field now produces just over 20 per cent. of the total British output.

(*b*) The "Marlstone" bed of the Middle Lias yields iron in two quite distinct areas, the Cleveland Hills of Yorkshire and the scarplands from Lincolnshire to Oxfordshire. The marlstone is not always an iron ore. Between North Yorkshire and South Lincolnshire it is barren; a gap separates the South Lincolnshire field from the Leicestershire field, and this again is separated by a barren area from the Banbury ore-bearing district. In North Yorkshire the marlstone crops out on the northern flanks of the Cleveland Hills, dipping gently south-eastwards. Owing to the resistant nature of the overlying beds which form the Hills the ore bed quickly disappears underground. It was first quarried in the outliers of Eston and Upleatham only a few miles from the Tees estuary. Almost at once adit mining (i.e. tunnels driven into the hillside) became necessary, and subsequently vertical shafts have been sunk to depths of as much as 700 feet.[1] The ore bed deteriorates south-eastwards and becomes divided by shale partings which quickly reduce its thickness from the 10 feet which is worked on the north-western edge of the field. The total amount of ore which has been removed from this field is about 350 million tons, and the beds are approaching exhaustion. Production has declined from 6 million tons in 1913 to under 2 million tons in the years 1931–1936, and about 1 million tons in 1949–1952—and if only this last rate of production is maintained

[1] The deepest mine is North Skelton, 720 feet.

the ore will be exhausted in about 45 years.[1] But the cost and difficulty of mining is increasing and this, combined with the reduction of output, has had considerable effect upon the economy of the Teesmouth industry (see p. 377).

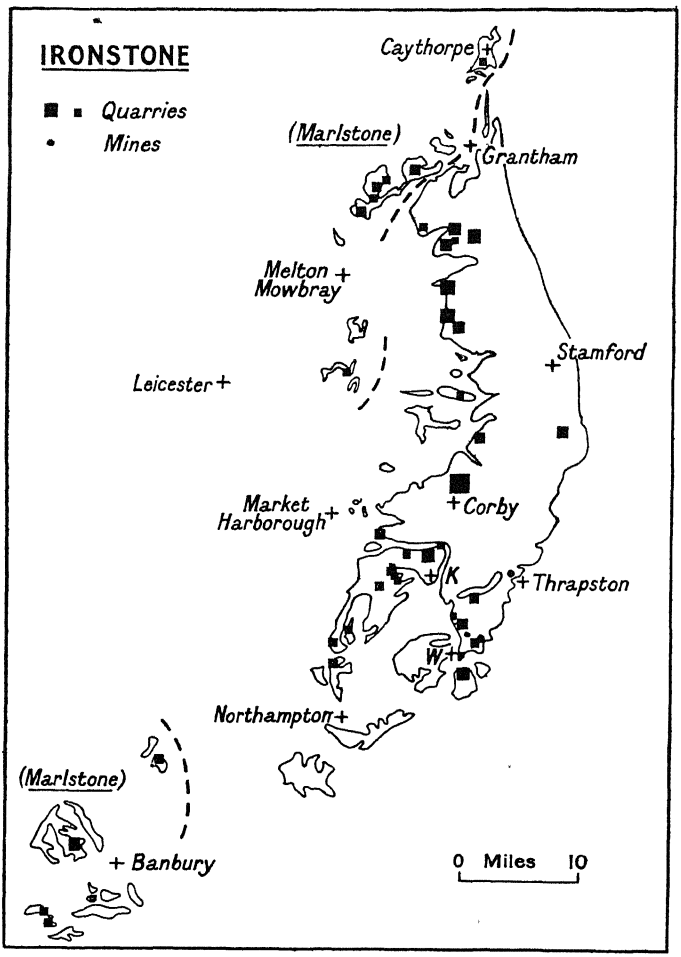


FIG. 194.—Marlstone and Northampton Sands Iron-ore Fields of the South-East Midlands

The large symbol for Corby represents several extensive quarries

The other marlstone areas are all worked opencast. The iron in these ores is the result of concentration due to the atmospheric weathering of lean ferruginous mudstones, and consequently, as soon as the bed disappears beneath the cover of newer deposits,

[1] *Mem. Geol. Surv., The Liassic Ironstone*, pp. 53–54.

where it has been protected from such weathering, the iron content diminishes so rapidly as to render the rock useless as an ore.[1] Consequently mining will probably never be necessary. The three separate fields are: (1) the Caythorpe district of South Lincolnshire (the smallest); (2) the Melton Mowbray ironstone ridge, around Holwell and Eaton in Leicestershire (the most important); (3) the Banbury district on the borders of Oxfordshire and Northamptonshire. In each of these areas the ore bed varies from about 6 to 12 feet in thickness, but often much has been lost through denudation.

All the marlstone districts produce lean ores. The Cleveland ore contains on the average about 28 per cent. of iron, and the quarried ores of the scarplands about 25 per cent.

(*c*) That portion of the Inferior Oolite formation in Northamptonshire, Rutland, and South Lincolnshire, known as the "Northampton Sands," is, and will continue to be, one of the vital factors in the British iron and steel industry.[2] It contains a bed of iron ore, generally between 6 and 12 feet in thickness, which is not only the richest of the Jurassic ores (iron content 30–33 per cent.) but also offers the most extensive reserve of ore of any of these fields. At the 1949–1951 rate of production, about 7 million tons a year, the ore will last for at least 175 years.[3] The field stretches, with slight interruptions due to deterioration and denudation, from Lincoln to Towcester and, unlike the marlstone of the neighbouring areas, the ore does not deteriorate eastwards under cover. Whilst the greater part is still obtained by opencast methods, at depths of up to 85 feet, there is therefore abundant prospect of the increase of shallow adit mining for several miles east of the outcrop. The Northampton Sands ore is siliceous, which makes it very suitable for foundry iron, and it is also higher in phosphorus than the other Jurassic ores, which makes the pig-iron produced from it suitable for the basic Bessemer process.[4]

In all the Jurassic ore fields, except Cleveland, the railway facilities have had a great bearing upon the working of the ore, and as the vales at the foot of the Marlstone and Inferior Oolite scarps provided excellent railway routes very little additional mineral line construction has been necessary.[5] In Cleveland the more dissected nature of the country led to the building of several special mineral lines and

[1] *The Liassic Ironstones*, pp. 95, 144.

[2] S. H. Beaver, "The Iron Industry of Northamptonshire, Rutland and South Lincolnshire," *Geography*, XVIII, 1933, pp. 102–117.

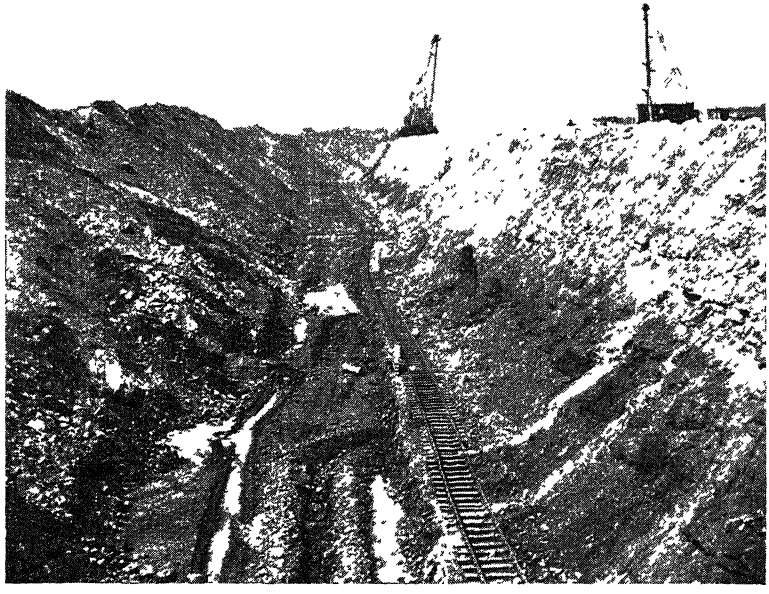
[3] *Mem. Geol. Surv., The Northampton Sand Ironstone*, p. 7.

[4] Iron containing at least 1·8 per cent. of phosphorus is necessary for the basic Bessemer process. Most iron-ores at present available in Britain contain too much phosphorus for the acid process and too little for basic Bessemer—one reason for the popularity of basic open-hearth.

[5] The most important mineral line is the Stainby and High Dyke branch, south of Grantham, which carries Northampton Sands ore from South Lincolnshire, on its way to Scunthorpe, Leicestershire, and Derbyshire.

connections with the existing tortuous branches of the North Eastern Railway (see Fig. 199).

Again, except for Middlesbrough, Scunthorpe, and more recently Corby, the working of the Jurassic ore fields has not given rise to any marked change in the distribution of population. The reason is to be found in (*a*) the scattered nature of the quarries, and in (*b*) the geological conditions which permit the use of mechanical appliances



[*Photo: S. H. Beaver*

FIG. 195.—Opencast ironstone mine, near Corby, Northants

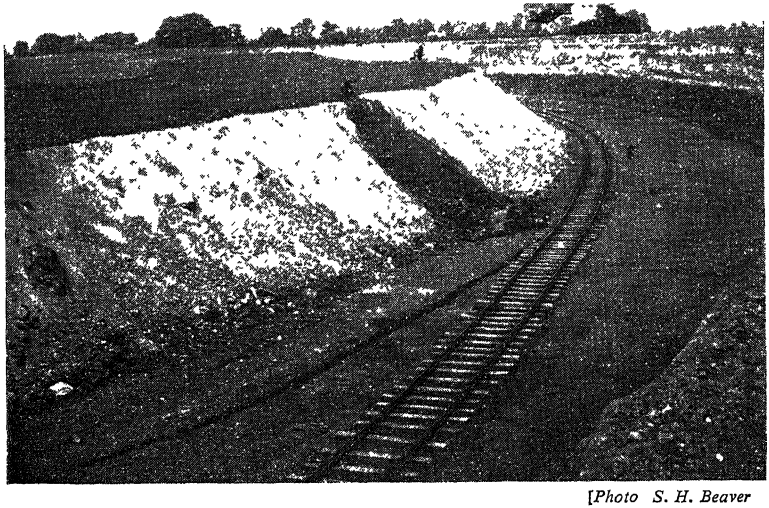
A large "walking dragline" removes the overburden and dumps it in "hill and dale" formation. Restoration is difficult

and consequently a small man-power. The use of mechanical excavators, however, mainly since the First World War, has greatly exaggerated the effect of ironstone quarrying on the landscape, for whereas in the days of hand working all the overburden and top soil were replaced and the land restored to agriculture, the mechanical shovel and dragline create large dumps of overburden in "hill-and-dale" formation, and the problems of afforestation and agricultural reinstatement are considerable.[1]

[1] See, for example, W. D. Evans, "The Open-cast Mining of Ironstone and Coal," *Geog. Journ.*, CIV., 1944, 102–119; also S. H. Beaver, *The Land of Britain, Part 58, Northamptonshire*, pp. 372–374.

4. *Miscellaneous Ore Deposits.*—Although of very small importance at the present time (since they provide less than 1 per cent. of the total output), certain other occurrences of iron ore have been important at various periods in the past and deserve passing notice.

In the Carboniferous Limestone of the Forest of Dean limonite (i.e. oxidised hæmatite) ($Fe_2O_3 + 3H_2O$), occurring in the same irregular fashion as the Cumberland hæmatites, was mined from



[*Photo S. H. Beaver*

FIG. 196.—Opencast ironstone mine, Cottesmore, Rutland

Dragline removes overburden, dumps it without forming "hill and dale," and subsequently replaces the soil, agricultural restoration is complete

Roman times, and it gave rise to an extensive iron industry during the charcoal smelting period. Production declined rapidly after 1880. A similar deposit in the same formation at Llanharry (Glamorgan) is the only one of the "other occurrences" which is still worked to any extent;[1] it supplements the imports of foreign ore at Cardiff and Port Talbot. The ore in the Upper Lias of Raasay,

[1] *Mem. Geol. Surv., Iron Ores*, Vol. X, "The Hæmatites of the Forest of Dean and South Wales," 1919.

IRON ORE PRODUCTION. (Thousand Tons)

Formation	1913	1921	1929	1931	1937	1942[2]	1949	1950	1951	1952	Average Iron content per cent.
HÆMATITE:											
Cumberland	1,361	243	1,245	613	737	594	350	342	374	403	48
Lancashire	406	92	146	96	120	21	—	—	—	—	(54)
Total	1,767	336	1,391	709	857	615	350	342	374	403	
JURASSIC:											
Lower Lias	*	543	2,842	1,423	3,047	3,672	3,207	3,155	3,380	3,432	20
Middle Lias, Cleveland	5,941	1,004	2,674	1,497	2,037	1,884	1,028	1,019	1,074	1,188	28
Middle Lias, other areas	*	632	1,801	1,056	2,001	2,702	1,638	1,538	2,319	2,387	24
Inferior Oolite	*	689	3,880	2,851	5,834	10,635	7,071	6,804	7,558	8,718	31
Total	12,572	2,868	11,198	6,827	12,919	18,894	12,944	12,517	14,332	15,724	
COAL MEASURES:											
N. and S. Staffs.	*	103	380	50	149	150	—	—	—	—	
Scotland	591	106	26	8	22	36	—	—	—	—	
Other areas	*	19	11	5	7	1	—	—	—	—	
Total	1,542	229	417	73	178	187	—	—	—	—	32
Other occurrences	116[1]	44	208	17	260	209	102	103	97	105	50[3]
TOTAL	15,997[1]	3,478	13,215	7,626	14,215	19,906	13,397	12,963	14,777	16,232	

* Not available, as figures given by counties only, not by formations.
[2] War peak year.
[1] Includes 60,000 tons from Antrim, Ireland.
[3] This figure is for the Llanharry hæmatite.

Scotland, was worked for a time, especially during the First World War, but its remoteness and low iron content (25 per cent.) rendered the cost prohibitive. The deposit of magnetic ore occurring in the Inferior Oolite of Rosedale, Yorks, has long since been worked out. The Corallian beds of Westbury (Wilts.) contain an iron ore which formerly fed the furnace there. The concealed Corallian rocks of the East Kent coalfield have also been found to contain similar ore. Certain bodies of bedded ore occurring in the Cretaceous rocks have also been of importance in the past. Most noticeable, of course, are the ironstones in the Wealden rocks of Sussex and Kent, which were for so long the chief sources of British iron. Deposits in the Lower Cretaceous near Claxby (Lincs.) are mined by a Scunthorpe firm, and at Seend (Wilts.) is a similar small deposit which for a short time fed a small ironworks.

IMPORT AND INTERNAL MOVEMENT OF IRON ORE

Despite the extensive reorganisation of the British iron and steel industry which was conducted during 1914–1918, when our capacity for producing basic steel from the home Jurassic ores was considerably enhanced, and despite the continued expansion of the Jurassic ore output, our imports of rich foreign ores have not proportionately diminished. But the reasons for importing ore are now rather different from those which influenced the first importation in the 'seventies. It was then that the demand for steel made by the acid processes became so great that Cumberland and Furness, even though their output rose to over 3 million tons yearly, could not supply sufficient non-phosphoric ore to feed the furnaces. By 1900 the amount imported had risen to 30 per cent. of the total quantity used. Our earliest imports came almost entirely from Spain, which possessed, in the province of Vizcaya, huge reserves of rich hæmatite ore, non-phosphoric and yielding 50–60 per cent. of iron. During the 'eighties, in fact, the greater part of the shipment from Bilbao, amounting to between 3 and 4 million tons per annum, was destined for British ports. Swedish ores, whilst being very rich in iron (mostly 60–70 per cent.) are mostly phosphoric, and this fact, combined with the lack of transport facilities, prevented any considerable import thereof before the discovery of the basic process. The first Swedish ores to arrive in this country came from central Sweden (the Grängesberg and Dannemora areas). The colossal magnetic deposits of Northern Sweden at Gällivare and Kirunavare were not available until railways were built to the coasts. Lulea began to ship ore in 1887, and the Norwegian port of Narvik began exporting Swedish ore in 1903. In more recent years (since 1900) considerable quantities of rich low-phosphorus ore have been

received from French and Spanish territories in North Africa, where there are extensive deposits of ore yielding over 50 per cent. of iron.

On an average some 8 to 9 million tons of ore are annually imported into Britain. Since the Second World War Sweden has more than regained the dominant position held before the war, and North African territories collectively remain the second important source, whilst Spain has fallen—largely owing to the exhaustion of its best deposits—to a quite minor place. Newfoundland has come into the picture again with its oolitic hæmatites from Wabana, and France once more sends Ordovician ores from the hinterland of Caen, in Normandy. Pre-Cambrian hæmatites from Sierra Leone have been arriving since 1933, when a Scottish steel company was largely responsible for opening up a new field, and somewhat similar ores from the state of Minas Geraes, in Brazil, have been imported since 1936. The latest source to be tapped is the lateritic ore at Conakry, in French West Africa, of which the first cargo arrived in 1953. The reason for such large imports, and from such distant

IRON ORE IMPORTS. (Thousand Tons)

Country	1913	1929	1931	1937	1943[2]	1949	1950	1951	1952	Average Iron content per cent.
Newfoundland	100	5	27	258	3	714	123	682	623	51
Sierra Leone	—	—	—	337	502	781	733	625	788	57
France	327	240	77	408	—	369	373	360	439	44
French N. Africa	1,038	1,354	562	2,165	306	2,295	2,233	2,193	2,572	50
Spain	4,525	2,619	888	930	265	807	750	772	663	50
Span. Morocco	—	68	20	185	542	491	433	346	253	62
Sweden and Norway[1]	854	1,238	446	2,387	—	3,146	3,443	3,472	3,716	63
Other Countries	386	99	88	280	276[3]	87	314[4]	297[5]	640[6]	—
Total	7,230	5,623	2,108	6,950	1,894	8,690	8,402	8,747	9,694	—

[1] Sweden and Norway have been added together owing to the difficulty, until recent years, of separating Swedish exports via Narvik from Norwegian exports. Norwegian exports in 1937 were 652 th. tons, in 1951 only 1 th. tons.
[2] Lowest war year—French and Scandinavian sources enemy-controlled.
[3] Includes Brazil, 262.
[4] Includes Yugoslavia, 193.
[5] Includes Brazil, 73, Yugoslavia, 50
[6] Includes Liberia, 234; Brazil, 100; Yugoslavia, 40.

sources, is now no longer merely the necessity for non-phosphoric ore for acid steel-making. True, most of our acid steel is derived from pig-iron smelted from foreign ores, but two much more cogent reasons for the imports are (*a*) the fact that the imported ores are in general about twice as rich as the home-produced Jurassic ores, and (*b*) the much lower fuel consumption per ton of pig-iron which the smelting of richer ores entails.[1] Bearing in mind also the coastal or near-coastal location of so much of the British smelting industry —a feature which was essentially a product of the importation of

[1] Jurassic ores need 22 to 24 cwts. of coke per ton of pig-iron, imported ores about 19 cwts.

foreign ore—it is easy to see why the imports continue. At the 1952 rate of pig-iron output, something like 30 million tons of Jurassic ore would be required every year, instead of the actual output of 16 million tons, and the coke requirement would be 13 million tons as against 11·4 millions, if only the home ores were used.

The iron ore imports are by no means evenly distributed amongst the various iron-smelting districts. Naturally enough, the coastal plants take most of the imported ore, but considerable quantities also make their way inland, even as far as the Black Country. In many cases (*e.g.* Middlesbrough, Cardiff, Port Talbot, Barrow) the ore is unloaded direct from the ship's hold on to the stock-piles of the ironworks, and it may be that the return freight of coal and finished iron and steel products which was formerly and may still be available helps to reduce the cost of such importation—though to an increasing extent the ore imports are carried in specially constructed ships which return in ballast. Middlesbrough, with over 30 blast furnaces along the Tees waterfront, takes upwards of one-third of all the ore imported (a good commentary on the much reduced significance of the Cleveland ores and on the momentum of 80 years' constant association with the import business). Its geographical position clearly marks it out as the chief recipient of Swedish ore. The South Wales ports import chiefly from North Africa and Sweden, the coastal plants of Cumberland and Furness take mostly low-phosphorus ores from Spain and elsewhere, the Scottish plants are important takers of Newfoundland and Sierra Leone ore as well as that from other sources, the Mersey ports import for the furnaces of Lancashire, North Wales, and the Midlands, Grimsby receives ore on behalf of some of the Yorkshire works, and London figures in the list by reason of the Thames-side works at Dagenham.

An extensive system of internal ore transport also exists in Britain, and it has an interesting geographical background. We have already seen that the presence of iron ores and coal in the same measures gave rise to iron industries in Staffordshire, Yorkshire (West Riding), Derbyshire, and South Wales. The cessation of the supply of Coal Measure ores has, however, left these areas without their local raw material, which must in consequence be drawn from farther afield. The Jurassic scarplands (excluding Cleveland), on the other hand, have huge ore supplies and no coal. Consequently, although furnaces exist in Northamptonshire, near Melton Mowbray (Leicestershire) and at Scunthorpe, a large proportion of the Jurassic ore is "exported" to these old-established regions. Most of the Frodingham ore is used in the local furnaces, but a considerable proportion of the Marlstone and Northampton Sands ores goes into the furnaces of the Midlands. An interesting transference of ore also takes place as a result of the calcareous nature of the Frodingham ore, which is

IMPORTS OF IRON ORE, BY PORTS AND COUNTRIES OF ORIGIN. (Thousand Tons)

Approaches	Ports of Entry	Total 1929	Total 1949	Total 1952	Country of Origin in 1952						
					Newfound-land	S. Leone	France & French N. Africa	Spain	Spanish Morocco	Sweden	Others
Thames and S. Coast .	London . . .	—	346	271	9	138	84	—	32	—	8
Bristol Chan.	P. Talbot, Cardiff, Newport. . .	1,384	1,802	2,203	199	98	883	132	11	692	188[1]
Mersey to Solway	Manchester, Birkenhead, Barrow, Workington .	514	1,632	1,896	28	58	694	309	200	481	126
Scotland .	Glasgow, Grangemouth . . .	902	1,171	1,268	213	185	340	71	—	393	66
N. E. Coast	Newcastle, Hartlepools, Middlesbrough .	2,540	3,328	3,594	174	306	932	140	31	1,819.	192[2]
Humber to Thames .	Immingham, Grimsby . .	278	231	357	—	—	82	—	—	264	11
Total .	. . . . .	5,623	8,609	9,589	623	784	2,915	652	274	3,650	691

[1] Includes Brazil, 73.

[2] Includes Liberia, 112.

so limy that it cannot be used alone in the furnace, but requires a siliceous complement—which is supplied by the ore from the Northampton Sands of Lincolnshire and Northamptonshire.[1] The decline in the Cleveland production is further reflected in the increasing amount of Northamptonshire and Rutland ore which is being sent to the Teesmouth furnaces. As a comment upon the facts enunciated above, Fig. 197 shows the destination of the Northampton Sands ore.

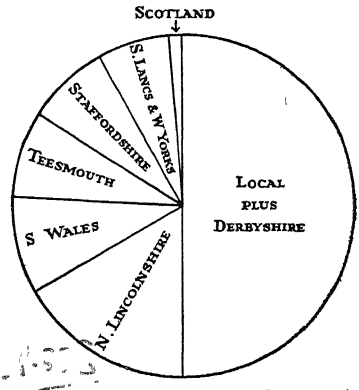


FIG. 197.—Diagram showing destination of Northampton Sands iron ore 1950

Other Raw Materials.—Other raw materials of vital importance to the iron and steel industry—apart from air and water[2]—include limestone, dolomite, refractories, manganese ore, alloying metals, and of course scrap. The first three of these have been briefly dealt with in Chapter XV; suffice it to say that Britain is well supplied with high-quality deposits, which are often most fortunately placed with respect to the iron and steel industries. *Manganese Ore* is employed, to the extent of nearly 1 cwt. per ton of pig-iron, mainly to neutralise the harmful effects of sulphur, and so is especially used in blast furnaces producing pig-iron for basic steel manufacture.[3] In the form of ferro-manganese (which is produced in blast furnaces just like pig-iron) it is used in steel melting as a de-oxidiser, especially in the Bessemer process, and it is also a constituent of high-manganese steel, which has exceptional qualities of toughness and resistance to wear. Of the alloying metals, *nickel*, used in stainless steel and for engineering purposes, *cobalt*, used in magnets and heat-resisting steels, *tungsten*, for high-speed tool steel, *molybdenum*, for high-speed and corrosion-resisting steels, and *chromium*, for tools, magnets, ball-bearings, and stainless steels, are the most important. All have to be imported.[4] About 1 million tons of alloy steels are

[1] Cf. the interchange, in Lorraine, of the limy ores of the Briey plateau and the siliceous ores of the Longwy and Nancy regions.

[2] Air is paradoxically the heaviest raw material of all, for anything from 3 to 7 *tons* of air may be used in a blast furnace to produce a ton of pig-iron, and a large furnace may use a ton of air per minute! Fortunately air is free and ubiquitous.

[3] Manganese ore comes mainly from the Gold Coast and India. Imports in 1952 were: from British West Africa 205 th. tons, India 152, South Africa 70; total 433 th. tons. The chief receiving ports are Middlesbrough, the Mersey, and Workington.

[4] Imports of ferro-alloy materials, 1951 (thousand tons): Chrome ore 132, Ferrochrome 22, Ferrosilicon 64, Cobalt 31, Nickel matte 34, Nickel ingots 5, Molybdenum ore 3, Other ferro-alloys 13.

produced every year—about three-quarters of it in Sheffield (see p. 388) and much of the rest in Scotland, in south Lancashire, and west and south Yorkshire, and North Wales.

Scrap.—In recent years some 9 to 10 million tons of scrap have been used annually in steel manufacture. The basic open-hearth furnaces are by far the largest consumers, but the electric furnaces, though with a much smaller output, work on little else but scrap. Nearly one-half of the scrap supply normally arises from the iron and steel works themselves, during the processes of manufacture, and the remainder is purchased from home sources (particularly re-rolling works and other works engaged in processing iron and steel, and also engineering works, ship-breaking yards, and other works having obsolete plant to dispose of) or imported from abroad.

THE SMELTING AND STEEL-MAKING DISTRICTS

Location Factors[1]

The British iron and steel industry affords numerous examples of "geographical inertia" or "industrial momentum"—the continuance of a human activity in a region, after some or all of the causes which give rise to that activity have ceased to operate. By reason of the size and cost of its plant the manufacture of iron and steel tends to be one of the most inert of industries, and, rather than abandon their works and move to a better site, manufacturers will go to great lengths to improve their efficiency, or their transport, or will specialise in certain types of produce. Slowly but surely, however, economic factors in the shape of competition from better situated producers will operate. If the industry originally set up has resulted in the accumulation of a large population in its neighbourhood, it is highly probable that production of some kind will continue by reason of the skilled labour there present; if the original industry was but small it must inevitably die out. Since much of our industry was built upon Coal Measure ores, which are now not worked at all, it follows that one of the main advantages formerly possessed by the iron industries of the coalfields has been lost. We must examine the producing areas individually in order to see how this change in location of the ore supplies has affected them.

It is important to realise that iron-smelting and steel-making can be and often are two quite separate industries, with different location factors. In the case of iron-smelting, between 3 and $3\frac{3}{4}$ tons of raw materials and fuel are consumed per ton of pig iron, and the iron ore, which is the largest single item, naturally exerts the greatest

[1] A concise summary of the main locational characteristics of the British iron and steel industry will be found in an article entitled "The Location of the British Steel Industry," in the Monthly Statistical Bulletin of the British Iron & Steel Federation, Vol. 25, No. 11, Nov. 1950.

influence on the location of the industry. Thus two major types of location are found—(*a*) on the ore-fields, particularly the low-grade Jurassic fields (*e.g.* Scunthorpe, Corby, Kettering, Melton Mowbray); (*b*) at ports, where foreign ores arrive (*e.g.* Middlesbrough,

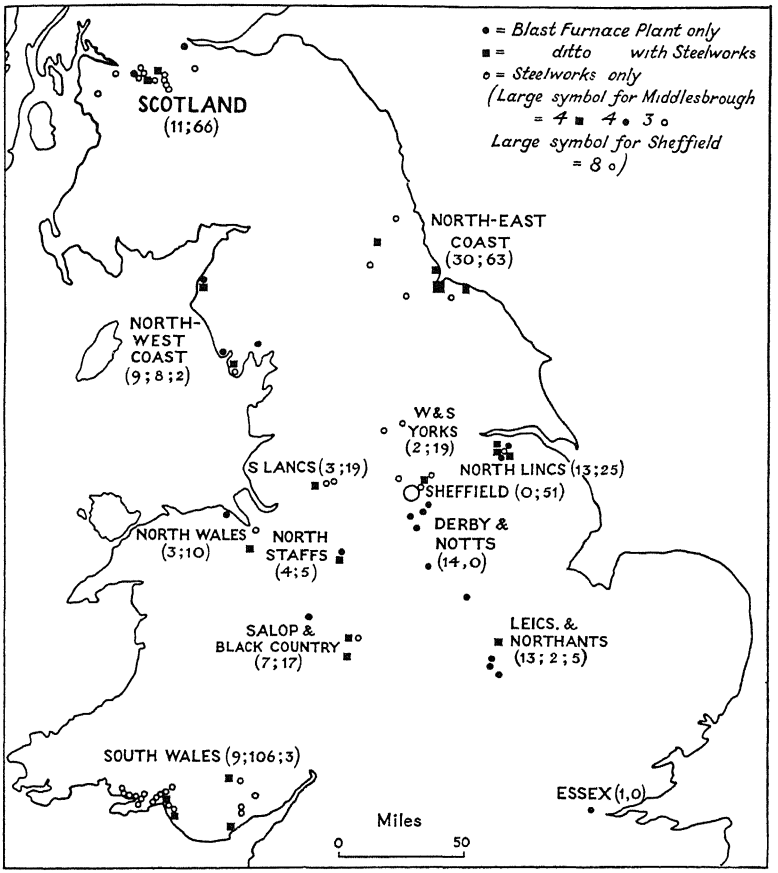


FIG. 198.—The British Iron and Steel Industry, 1952

The first figure in brackets is the number of blast furnaces (total or Great Britain 119), the second of open-hearth steel furnaces (total 391); the third (where present) of Bessemer converters (total 10). By way of comparison, the following figures represent the number of blast furnaces in existence in 1937 and (in brackets) in 1921 Scotland 53 (102), N E. Coast 56 (114); N.W. Coast 18 (47); S. Lancs 4 (13); W. and S. Yorks 8 (18), N. Lincs 17 (23); Derby and Notts 13 (49), Leics and Northants 21 (23), N. Wales 3 (3), N. Staffs 6 (15), Salop and Black Country 23 (43); S. Wales 12 (33); Essex 1 (0). Total 285 (486)

Workington, Cardiff, Dagenham—the first two having also the original advantage of nearby ore supplies, the third of a nearby source of coking coal). But the "momentum" referred to above is also responsible for a third type of location—(*c*) on coalfields, where the original works were based on local Coal Measures ironstones as

well as suitable fuel (*e.g.* Consett, Chesterfield, Coatbridge, Bilston, Stoke-on-Trent). The steel-making industry has as its main raw materials iron, either molten or in pig form, and scrap. It may be located (*a*) adjacent to a smelting works, where molten iron from the blast furnaces can be converted directly, without loss of heat, into steel; this type of situation—the "integrated" works—is coming increasingly to dominate the British iron and steel industry (*e.g.* Middlesbrough, Scunthorpe, Workington, Ebbw Vale, Corby, Margam); (*b*) adjacent to its market (*e.g.* western South Wales, where almost all the output goes into the tinplate mills; and many scattered and mainly small works in various parts of the country which form part of steel foundries and engineering works); (*c*) in an engineering district where abundant scrap is locally available and the engineering works also form a market for the output (*e.g.* Wednesbury, Motherwell).

TABLE OF PIG-IRON PRODUCTION (BY DISTRICTS)
(Thousand Tons)

District	1913	1921	1929	1931	1937	1940[2]	1950	1951	1952
Derby, Leics., Notts, Northants, Essex[1]	1,166	348	1,174	979	1,938	1,787	2,209	2,150	2,262
Lancs and Yorks.	503	219	472	205	476	401	437	448	472
Lincolnshire	450	107	865	412	1,043	1,308	1,239	1,259	1,505
N.E. Coast	3,869	1,054	2,349	1,137	2,429	1,934	2,402	2,337	2,601
Scotland	1,369	289	607	154	497	659	739	790	886
Staffs, Salop, Worcs, Warwick	851	194	439	202	470	447	551	543	523
S. Wales and Monmouth	889	121	926	280	814	962	1,232	1,351	1,545
N.W. Coast	1,163	284	755	404	825	705	824	792	933
Total	10,260	2,616	7,589	3,773	8,493	8,205	9,633	9,669	10,728

[1] Essex only since 1934. [2] War peak year—see footnote to next table.

TABLE OF STEEL PRODUCTION (INGOTS AND CASTINGS) (BY DISTRICTS)
(Thousand Tons)

District	1913	1921	1929	1931	1937	1943[1]	1950	1951	1952
Derby, Northants, Notts, Lancs, Yorks (excluding Sheffield), N. Wales	512	403	772	363	1,511	1,683	2,048	1,997	2,087
Lincolnshire	241	90	734	392	1,299	1,243	1,562	1,458	1,651
N.E. Coast	2,031	1,003	2,208	1,142	2,825	2,525	3,353	3,201	3,238
Scotland	1,421	583	1,582	676	1,895	2,031	2,426	2,115	2,133
Staffs, Salop, Warwick, Worcs	365	189	555	419	702	727	856	862	926
S. Wales and Monmouth	1,807	855	2,336	1,274	2,629	2,609	3,407	3,475	3,720
Sheffield	879	461	1,217	776	1,739	1,960	2,218	2,137	2,294
N.W. Coast	398	120	233	161	385	253	423	393	368
Total	7,664	3,703	9,636	5,203	12,984	13,031	16,293	15,638	16,418

[1] War peak year. The wartime peak of steel production was reached later than that of pig-iron, for several sources of foreign ore were cut off and scrap was substituted. Thus the 1940 steel output consumed 6,731 th. tons of pig-iron and 7,181 th. tons of scrap; the 1943 steel output consumed 6,124 th. tons of pig-iron and 7,965 th. tons of scrap.

Naturally enough, in a country in which the industries are as old-established as they are in Britain (only three new localities of major importance have been added to the iron and steel map during the present century), and in which distances between coal, ore, and ports are in no case great, many works fall into more than one category.

(1) *Scotland.*[1]—All the Scottish smelting works were established between 1760 and 1860. Their location is thus "rather an interesting relic of quite another age."[2] The first, apart from a few charcoal furnaces erected on the west coast to use local timber and Lancashire hæmatite, was established by a Sheffield ironmaster at Carron, near Falkirk, in 1760, on a site within a few miles of the coast, where a good water supply was available, and close to clayband ore and coal reserves. The works quickly became one of the largest and most famous in Europe. Progress generally was particularly marked, however, after Neilson in 1828 rendered the blackband ores more efficiently usable by means of the hot blast. The output, only 9,000 tons in 1806, rose to 210,000 tons in 1840, and in the 'fifties, with over 150 furnaces available, Scotland was producing a quarter of the entire British output of pig-iron. After 1880 the production of blackband ores began rapidly to decline, and the ironworks, finding their ore supplies partly cut off, were obliged to import extensively from abroad. By distribution the smelting works fell into two main groups. The central group, clustered on the Lanarkshire coalfield, had its chief centres at Coatbridge, Airdrie, Motherwell, Wishaw, and Glasgow. Here the Monkland Canal and the Clyde, and later the railways, provided suitable means of transport for the bulky iron products, whilst the local "splint" coals[3] and the blackband ores were the basis of this industry (cf. Fig. 178 and Fig. 192). The North Ayrshire group was centred on Irvine and Kilbirnie, with outlying plants at Lugar and Muirkirk; it had the same basis of ore and fuel.

The prosperity of the Scottish ironworks was seriously undermined by the falling off in the local ore supply, and the situation was aggravated by the approaching exhaustion of the "splint" coals, which were used raw in the furnaces. These circumstances, together with the periods of depression which characterised the inter-war years, were largely responsible for completely changing the character of the Scottish iron-smelting industry, by weeding out those works

[1] See H. Hamilton, *The Industrial Revolution in Scotland*, Chapters VII and VIII, for an excellent account of the development of the Scottish iron industry.

[2] P. R. Crowe, "The Scottish Coalfields," *Scot. Geog. Mag.*, XLV, 1929, 321–337.

[3] The "Splint" coal, one of the most constant of the Lanarkshire seams, is of a hard splinty character specially valuable for furnace purposes. "It comes from the pit in big hard blocks which do not readily break up in the furnace under the weight of the overlying material, and the draught is thus kept open." (*Mem. Geol. Surv.*, "Economic Geology of the Central Coalfield of Scotland, Area V," 1926. 73.)

whose equipment or situation rendered them uneconomic. Pig-iron production is now concentrated on four plants only—two in Glasgow, one at Coatbridge, and one at Carron. Of nearly 90 furnaces which existed in 1930 less than 20 remain; several complete works have been demolished. This concentration on a few large plants has been accompanied and aided by the production of coke from certain seams, such as the Kilsyth coking coal, which occur in the Lower Limestone Group (of Carboniferous Limestone age) in North Lanarkshire and Stirlingshire. New large furnaces, comparable with those in other parts of Britain, have been erected to use foreign ore and Scottish coke, and the largest works in Glasgow and Coatbridge are each fully integrated and possess their own coke ovens. Thus the small furnace producing foundry iron from local raw materials has vanished from the Scottish iron industry. Even the Carron works now imports ore *via* Grangemouth.

The steel industry is located for the most part in the neighbourhood of Coatbridge, Motherwell, Wishaw, and Glasgow. It grew up apart from the blast furnaces, depending originally on imported hæmatite pig-iron and scrap from the local shipbuilding, ship-breaking, and engineering industries. During and after 1914–1918 much of the plant was adapted for the production of basic steel, and about 85 per cent. of the output is now of the basic open-hearth variety. Much of it, together with large quantities of imported semi-finished steel, goes into the local shipbuilding and engineering industries (see Chapter XVII). Important recent developments (largely due to the Second World War) are the production of increasing quantities of alloy steel, and the use of the electric furnace.

In addition to pig-iron and steel production, Scotland still has a small wrought-iron industry, centred on Coatbridge.

(2) *Teesmouth.*[1] The advantages of Teesmouth for the setting up of iron and steel industries were unique. An abundant supply of ore in the Cleveland Hills, less than five miles away from tide water at first, and still well within 20 miles of Middlesbrough; ample supplies of the finest coking coal in the kingdom from south-west Durham, only 25 miles away and available by existing railways; limestone in abundance from the Carboniferous Limestone in Weardale and dolomite from the Permian of East Durham; and a seaboard situation favourable, with the improvement of the estuary, for the export of the bulky products. It is little wonder that within 25 years of the commencement of the industry Teesmouth was producing 1¾ million tons of pig-iron, or close on 30 per cent. of the total British output. Moreover, after the introduction of the acid steel processes the coastal situation favoured the import of rich Spanish

[1] See Ll. Rodwell Jones, *North England*, 40–54; Frey, "Iron and Steel Industry of the Middlesbrough District," *Econ. Geog.*, 1929; Appleton, "Iron and Steel Industry of the Cleveland District," *Econ. Geog.*, 1929.

ores, which were rendered cheaper by the availability of a return cargo of coal from the adjacent coalfield, whilst the abundance of flat land alongside the estuary allowed ample room for the expansion of the works. All these advantages enabled Teesmouth to build up the greatest iron and steel industry in the whole of Britain. The serious depletion of the local ores, however, combined with the stimulus which was given to the industry during 1914–1918, brought about changes in the nature of the industry. The pig-iron output has never again even approached the 1913 total (see table on p. 374), and only about ten per cent. of it is now made from Cleveland ore. Sweden and North Africa supply rich ores from abroad; Northamptonshire and South Lincolnshire send $\frac{3}{4}$ of a million tons per

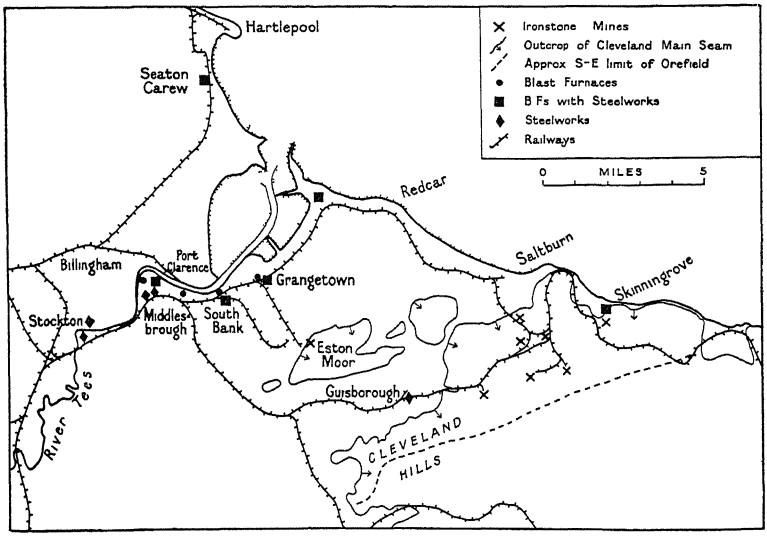


FIG. 199.—Map illustrating the Teesmouth iron and steel industry

annum of lean ores and Cumberland sends a little hæmatite. The bulk of the pig-iron is converted into basic steel, and the once famous foundry-iron production has virtually ceased. Both pig-iron and steel are exported to Scotland and other coastal centres of the industry. Much of the hæmatite pig-iron and steel made is sent to Sheffield for working up into the finer types of steel products. A large proportion of the steel production is absorbed by the local engineering and shipbuilding industries. The expansion of the steel industry during the First World War resulted in a vast improvement of the existing Teesmouth steelworks plant and the erection of a new works at Redcar. Subsequently foreign competition resulted in renewed efforts to modernise the plant and to reduce working costs. As a result huge combines were formed, bringing under a single

control the coke and ore supplies, the furnaces, and the steelworks, and even including the engineering industry and the marketing of the produce. An excellent example is furnished by Dorman Long, which united Dorman, Long & Co., Bell Bros., North-Eastern Steel Co., Bolckow, Vaughan & Co., and other smaller establishments. The industry was "rationalised" and inefficient plant eliminated. For example, Port Clarence works (opposite Middlesbrough), with 11 blast furnaces, closed down in 1930 and was later demolished.

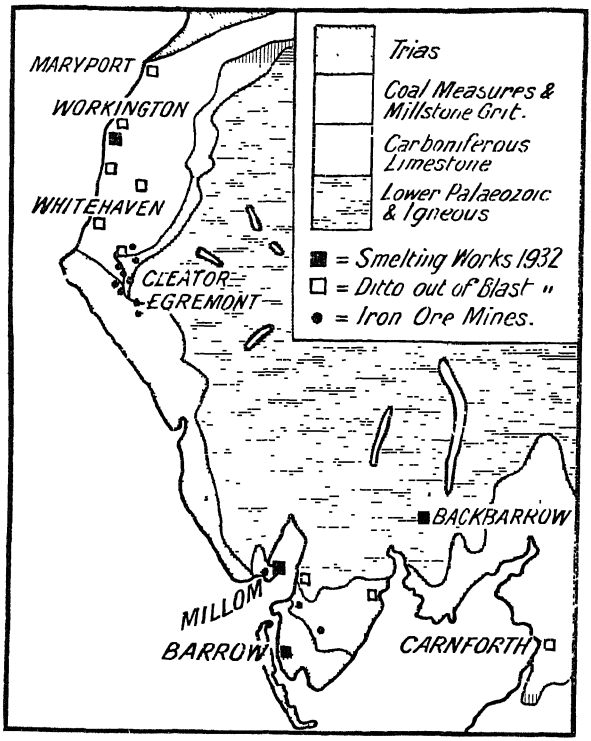


FIG. 200.—Map illustrating the West Coast iron industry

Almost all the works marked as inactive in 1932 have since been demolished; those active in 1932 were still working in 1952. Only three or four of the mines remained in 1952, and none in the Furness peninsula

The chief works in the north-east coast area away from the Tees are at Seaton Carew just north of the estuary, at Skinningrove, to the east, and at Consett.[1] These outlying centres are supported

[1] The location of the Consett works depended on the existence of a limited amount of clayband ironstone in the Coal Measures of the immediate vicinity; but as against its present disadvantageous situation regarding imported ore, it lies almost on top of the coking coal requirements, and not far from excellent limestone and silica-rock deposits It is a fully integrated works.

almost entirely by foreign ore, though Skinningrove still uses some Cleveland ore which is mined close to the works.

(3) *The West Coast.*—The geographical basis of the iron and steel industry in West Cumberland and Furness was simple. Large supplies of rich hæmatite ore occurred within a few miles of the coast; the ore was obtained from the Carboniferous Limestone, which could be used as a flux; and the Durham coke lay not far away (by rail) across the Pennines (for the local Cumberland coal is not of first-class coking quality). Almost without exception, then, the works were located on, or quite close to, the sea-shore, and consequently, owing to the absence of a large industrial market in the vicinity, it was the export trade in pig-iron which was chiefly developed, the exports being to Sheffield, coastwise to Belfast, South Wales, and Scotland, and abroad. The first works (apart from the ancient charcoal furnaces)[1] were erected in 1841, but the greatest development came after the introduction of Bessemer steel, and nine new works made their appearance in as many years, between 1870 and 1879. Much of the steel production is absorbed in the engineering and ship-building industries which have grown up at Barrow and Workington. The production of both pig-iron and steel has been rising since the reconstruction which followed the great depression of the early 1930s, and is approaching the 1913 figure again—but with many fewer furnaces and with a considerable import of foreign low-phosphorus ores to supplement the much reduced local hæmatite output.

(4) *South Wales.*—South Wales illustrates admirably the changes that have been brought about in the location of the iron and steel industry owing to changes in geographical values. The earliest working after the introduction of coke smelting was in the north-eastern part of the coalfield, in the uplands at the head of numerous valleys which flow down towards Cardiff and Newport; along a narrow belt, from Aberdare through Merthyr Tydfil, Rhymney, Tredegar, Ebbw Vale, and Blaenavon to Pontypool. Here the clay-band ores were richest and the gentle dip of the Coal Measures on this northern outcrop of the coalfield permitted the easy extraction of the ores and coal from quarries and adit mines. The setting up of the industry in this inland situation necessitated the growth of improved methods of transport, and the construction of tram-roads and canals to the coast further stimulated the iron trade and encouraged the development of docks at Newport and Cardiff for exporting iron and coal (Fig. 201). There were other smelting works at Maesteg and Cwmavon, where the median anticline of the

[1] The ancient Backbarrow works, founded in 1711, continued (in a modernised condition) to make charcoal iron well into the present century; with the virtual extinction of the local charcoal-burning industry it then turned to the use of coke, and it remains as a rather odd, out-of-the-way relic.

coalfield (cf. p. 312) brought coal and ironstone to the surface. A vast industry developed, reaching its maximum in the 1860s when there were 200 blast furnaces and over 1,350 puddling furnaces for wrought iron manufacture.

The introduction of the acid steel industry in the 'sixties, with its accompanying need for non-phosphoric ore, commenced slowly but surely to undermine the basis upon which the existing iron industry had been built. Interest now centred on the import of rich hæmatite from Spain. The momentum of the north-eastern area sufficed to attract the steel industry to that area, and several large works grew out of the existing smelting and wrought-iron works. Dowlais was in fact the largest works in the world at one time. But this prosperity could not last; all the hæmatite ore had to be dragged up the valleys

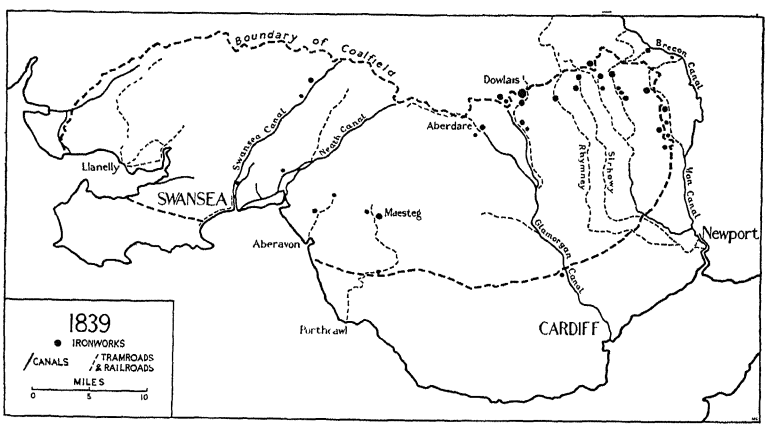


FIG. 201.—South Wales iron smelting works, canals and chief tramroads, 1839

from the ports, and the introduction of the basic process gave no relief since by that time the local clayband ores were either exhausted or rapidly becoming uneconomic to work; and competition from better-situated producers in other parts of Britain was intense. So one by one, from the 1880s onwards, the great works—Dowlais, Cyfarthfa, Sirhowy, Blaenavon, and others—closed down, and the last survivor, Ebbw Vale, ceased work in 1929.

Meanwhile, however, two other trends had developed. First, following the discovery by Siemens in the late 'seventies that mild open-hearth steel made an excellent foundation for tinplate, several new steelworks—based on imported pig-iron and scrap—were set up in the south-western part of the coalfield, close to the ports and within the area where the tinplate industry was already largely concentrated—as at Llanelly, Bynea, Gorseinon, Gowerton, Swansea, Briton Ferry, and Port Talbot. A somewhat similar development took place in the east—*e.g.* at Panteg and Pontymister.

Secondly, new "integrated" iron and steel works were set up on the coast—indeed, on the dock-side—at Cardiff and at Margam (Port Talbot). Here, obviously, with Spanish, French, and North African ores readily available by sea, was a better situation for the industry than 15 miles inland and 1,000 feet above sea level.

The extinction of the industry in the north-eastern area was the major factor in the severe incidence of the depression, with its attendant unemployment problem, in that part of South Wales, between the wars. The existence of so much "social capital" in the area, however, prompted the Government in 1936 to encourage the firm of Richard Thomas & Co., which at that time was considering abandoning its interests in South Wales and setting up a new plant at Scunthorpe, to embark on a large scheme for the rehabilitation of Ebbw Vale; and at a cost of over £10 millions, a vast new integrated works was constructed, with blast furnaces, coke ovens, basic Bessemer and open-hearth furnaces, continuous hot-strip mill and tinplate works. The Bessemer process was first chosen as being less expensive in fuel than the open-hearth, and the need for high-phosphorus iron for basic Bessemer steel entails the importation by rail of Northampton Sands ironstone from the Wellingborough district (where the Irthlingborough mines had been worked by the previous Ebbw Vale company). Ebbw Vale is now once again one of the greatest single producing units in the country.

The success of Ebbw Vale, and particularly the economies to be reaped in tinplate manufacture by the hot-strip process (see below, p. 394) prompted the formation by several South Wales steel firms of the Steel Company of Wales, which in 1947 began a £60 million project for the reconstruction of the Margam iron and steel works (which is of course dependent on foreign ores) and the installation alongside it of a continuous hot-strip mill (the "Abbey" works), together with an associated cold rolling mill and tinning works at Trostre, near Llanelly. The planned annual output of these works is $1\frac{3}{4}$ million tons of steel strip. These two vast tinplate producing concerns, Ebbw Vale and Margam—Trostre, will render redundant a large proportion of the existing tinplate mills (cf. p. 395); but the hot-strip process also produces other sorts of steel sheet besides that for tinplate.

So the present picture in South Wales, with a few very large integrated works and a few separate steelworks, is indeed a very different one from that of a hundred years ago—more so, perhaps, than in any other area except Scotland, and the differences are due fundamentally to changes in industrial technique and in the sources of raw materials.

(5) *Lincolnshire.*[1]—In Lincolnshire, where the first furnace was

[1] O. D. Kendall, "Iron and Steel Industry of Scunthorpe," *Econ. Geog.*, XIV 1938, 271–281.

lighted in 1864, the localisation of the works is due entirely to the existence of the thick, though lean, Lower Lias ore in the neighbourhood of Scunthorpe and Frodingham. The greater thickness of the ore-bed here and its occurrence over a comparatively small and compact area has permitted a far greater concentration of the smelting industry on this field than is the case, for example, in Northamptonshire. The area is well situated with regard to fuel supplies and export facilities. The nearest mines of the Yorkshire coalfield (which produces good coking coal) are less than 15 miles to the west, and the port of Grimsby lies only 25 miles to the east. The limy nature of the ore, as we have seen, necessitates the import of siliceous Northampton Sands ore from South Lincolnshire, but the presence of appreciable quantities of manganese renders it rather more suitable for basic open-hearth steel making than the Northamptonshire ore. Owing to this fact, and to the compact nature of the industry, this group of works received a marked stimulus during 1914–1918, and the production of steel is now seven or eight times what it was in 1913. The plant comprises three huge integrated works, one of which, the Appleby-Frodingham plant of United Steel Co., is the largest in Britain. As the ironstone field is estimated to have a future of at least 200 years before it, and as the Yorkshire coal mines are creeping nearer and nearer to it from the west, the area will undoubtedly increase in importance. The momentum of other areas may prevent its participation to any great extent in the engineering industry, but it will remain a pillar of strength as a producer of the raw materials of that industry. Pig-iron is sent to Yorkshire, Lancashire, Staffordshire, and Scotland, and much of the steel output goes into constructional engineering.

(6) *The Western Midlands* (Black Country, etc.).—Even in the days of charcoal smelting South Staffordshire, by virtue of its accessible coal supplies,[1] developed an extensive finished iron industry based upon bar-iron obtained either from Shropshire and Worcestershire or imported *via* the River Severn from the Forest of Dean and Sweden. Furnaces, forges, and slitting mills made use of every available stream for power, and there was especial concentration in the Stour valley.[2] The introduction of coke smelting at once placed the Coalbrookdale area and South Staffordshire in a more favourable position. Rich coal and iron seams occurred in the same measures, a supply of flux was locally available in the Wenlock limestone hills of Dudley, and the people were already skilled in metal working. The result was the creation of that vast smelting industry which earned for the South Staffordshire region its unenviable title of

[1] Coal furnaces were used to heat the iron for forging.

[2] B. L. C. Johnson: "The Stour Valley Iron Industry in the late Seventeenth Century," *Trans. Worcestershire Archæological Soc.*, 1950, 35–46.

"Black Country."[1] At the beginning of the nineteenth century the two counties of Staffordshire and Shropshire accounted for 40 per cent. of the pig-iron production of Great Britain. In North Staffordshire the clayband ores and coking coals of the western part of the coalfield began to be used in the late eighteenth century, and the utilisation of the blackband ores after 1840 brought the smelting industry into the Potteries area.

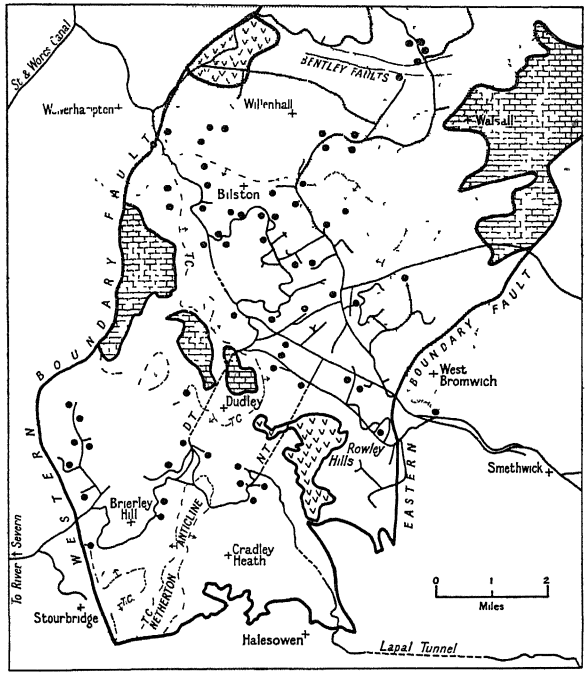


FIG. 202.—The Black Country Iron Industry in the mid-19th century

Within the coalfield are shown (i) Exposed Coal Measures (covered in some areas, however, by Etruria Marl), (ii) Glacial Drift (stippled); (iii) Carboniferous volcanics (V-symbol), (iv) Silurian inliers (brickwork symbol); (v) Outcrop of Thick Coal (T C), with arrow indicating dip. Also shown are all the canals and branches, and (black dots) all the ironworks in existence in the 1850s. Note that almost every ironworks lay alongside a canal, and many were served by their own branches and basins. For the ultimate destinations of the canals passing beyond the edge of the map, see Fig. 269

The Black Country reached its peak in iron production in the late 'fifties, with about 180 blast furnaces, but already the local ironstones were showing signs of physical and economic exhaustion and a declining iron output became increasingly dependent on Northamptonshire ores.[2] Wrought-iron production, partly assisted by

[1] See *Birmingham and its Regional Setting*, British Association Handbook, 1950, pp. 161–186, 193–210, and 229–248.

[2] The South Staffordshire output of pig-iron was 597,000 tons in 1858. By 1884 it had declined to 279,000 tons, 80 per cent. of which was made from Northamptonshire ore.

Northamptonshire pig-iron, went on increasing until the 'seventies, when there were over 2,100 puddling furnaces, but after that appreciable changes took place; iron smelting declined still further, and steel manufacture began to replace that of wrought iron, with an increasing concentration on iron-using industries rather than iron-making. There are now only ten furnaces left in Staffordshire, and there is but one small works left on the Shropshire coalfield, at Oakengates. In North Staffordshire, near Stoke-on-Trent, and in the south, at Bilston, Jurassic ores from Northamptonshire and Oxfordshire are used, with some richer foreign ores. Stoke, it is true, has coking coal on the spot, and the Shelton works is fully integrated, but Bilston's coke is derived from South Wales. The West Midland iron and steel industry is thus running on "geographical momentum."[1] The true Black Country now produces but little coal and no iron ore, and, as a result, has come to specialise to an increasing extent in steel-making, fostered to a large extent by the abundance of scrap available from the engineering industries. There are steelworks at Bilston, Round Oak, and Wednesbury. Large quantities of foundry pig-iron are imported from Northamptonshire for working up into cast-iron articles, and this area is one of the most important districts in Britain still using forge pig-iron for making wrought-iron goods, particularly ships' chains. It is also the principal district in Britain for the re-rolling of steel.

(7) *The remaining areas* (except Sheffield).—The remainder of the British iron and steel industry falls into several groups. In general, pig-iron for foundry work is rather more important than steel, though the steel output is increasing, largely owing to the developments in Northamptonshire. Most of the works are supplied with ore from the marlstone of Oxfordshire and Leicestershire, and from the Northampton Sands field (cf. Fig. 197). Three principal groups of furnaces may be noted: (*i*) *Derbyshire and south Yorkshire*, grouped around three centres, in south Derbyshire (Ilkeston), in north-east Derbyshire (Chesterfield), and in south Yorkshire (Rotherham). All these works owe their origin to the clayband ores which were formerly mined in conjunction with the valuable coal seams which occur near the base of the Middle Coal Measures. In a fourth area, around Leeds and Bradford, the Black Bed ironstone and the Better Bed coal were used, and this region was long famous for "Best Yorkshire" wrought iron. The last surviving works, at Low Moor, was dismantled in 1938, and an alloy steel works has taken its place. In south Yorkshire the Tankersley ironstone and the Silkstone and Park Gate coals provided the basis for the industry

[1] An interesting survival of a former age is to be found at the Earl of Dudley's Round Oak works, at Brierley Hill, where a cold-blast furnace is still available for producing special iron for making the outside surface of rolls for steel mills, and for chains. Another cold-blast furnace existed until recently at Netherton, near Dudley.

which still flourishes in the Rotherham area, where iron, steel and foundry products (notably grates and stoves) are made. Farther south, in the Chesterfield area, the Brimington anticline brought the Silkstone coal and several useful ironstone seams nearer to the surface and so localised the furnaces at Sheepbridge and Staveley, where the speciality is iron pipes for water and gas mains. At Clay Cross an ironworks—which is still active—was started in 1847 to provide an outlet for the surplus coke produced by the ovens erected to supply Midland Railway locomotives—perhaps the oddest location factor in the whole of the British iron industry. Farther south still

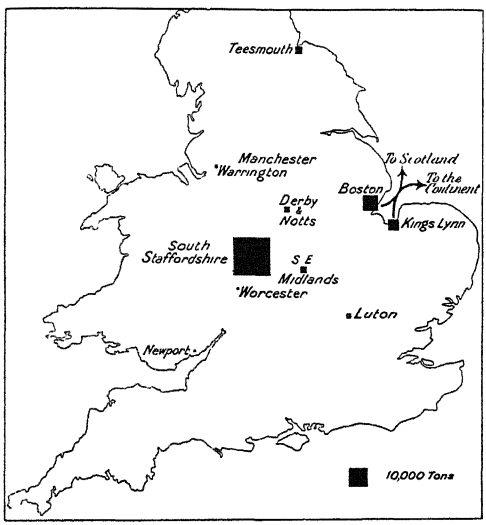


FIG. 203 —Map showing the destination of pig-iron made at Wellingborough, Northamptonshire, in 1929

Total tonnage forwarded, 58,458 tons. This map, based upon a special investigation, is given as an example of the areas supplied with pig-iron made on the Northamptonshire orefield. The only feature likely to have altered is the virtual cessation of coastwise and continental exports

the Erewash valley anticline, bringing the valuable Top Hard (Barnsley) coal to the surface, localised a group of furnaces of which the Stanton works near Ilkeston, world-famous for iron pipes, is the only survivor. All these works now depend entirely on Jurassic ores, and their output (except at Park Gate) is concerned far more with pig-iron and foundry products than with steel. (*ii*) *South Lancashire and North Wales.*—The existence of a small quantity of coking coal and the local demand for textile machinery, together with the availability of imported ore supplies *via* Liverpool, gave rise to the iron industry in South Lancashire, and in North Wales the usual association of coal and ironstone in the Flint and Denbigh coalfield led to its development. What remains is either modern or

specialised, however. The smelting works at Wigan and Darwen have long been extinct, and the only works in South Lancashire is the modern plant at Irlam, alongside the Ship Canal; this depends on ore from Northamptonshire and abroad. The huge steelworks at Shotton, to which blast furnaces and coke ovens were added in 1953, are likewise modern; though on Deeside they depend on Birkenhead for imports and exports; the Mostyn ironworks, also on the Dee estuary, makes ferro-alloys, and the only survivor of the old industrial régime is the Brymbo iron and steel works, near Wrexham, which played almost as important a part as Coalbrookdale in the early history of the iron industry. (*iii*) *Northamptonshire and Leicestershire*.—In Northamptonshire, as at Frodingham, the local ore supplies gave rise to an industry away from the coalfields.[1] The start was slow, for the inland situation and the great momentum possessed by the Midlands as iron producers prevented the rise of an industry comparable with that which developed, based on similar ores, at Teesmouth. Moreover, the distance from coal and from the coast prevented the rise of a basic steel industry, and the phosphoric ore produces an easily flowing pig-iron which is admirably adapted for making cast-iron articles. Until recently therefore the area remained as a producer mainly of foundry and forge pig-iron for (*a*) the vast metallurgical industries of Staffordshire; (*b*) the scattered foundry and engineering industries of the south-eastern portion of Great Britain. The chief centres of the smelting industry are near Melton Mowbray, in Leicestershire, and at Kettering, Wellingborough, and Corby, in Northamptonshire. The last-named village, which saw its first blast furnace in 1910, has since 1933 been transformed into an industrial town[2] by one of the outstanding developments of the century. Messrs. Stewarts and Lloyds have erected a huge plant, containing coke ovens, blast furnaces, Bessemer and open-hearth steel furnaces, continuous hot-strip rolling mill, and a tube factory, in the heart of the Northamptonshire ironfield. The distance from a coalfield, the requirements of the tube industry, and the phosphoric character of the ores, led to the adoption of the basic Bessemer process. So Northamptonshire is at last following the same industrial path as Lorraine, and its future prospects appear to be very bright.

Last amongst the "remaining areas" is Essex. Here, in 1934, at Dagenham on Thames-side, the Ford Motor Co. established coke ovens and a blast furnace, with a motor vehicle assembly plant alongside. Both ore and coal arrive by sea.

[1] S. H. Beaver, "The Development of the Northamptonshire Iron Industry, 1851–1930" (Chapter III of *London Essays in Geography*, London, Longmans, 1951).

[2] K. C. Edwards, "Corby—a New Town in the Midlands," *Town Planning Rev.* XXII, 1951, 122–131.

(8) *Sheffield.*[1]—Sheffield must be considered separately, because its industry is so very different from that of the remainder of the region in which it is situated. In common with the neighbouring areas, the Don valley and its tributaries developed, as early as the twelfth century, an iron industry based upon Coal Measure ironstones, local charcoal supplies, and plentiful water-power. The Carboniferous gritstones of this region making excellent grindstone material, specialisation commenced in the manufacture of cutlery, and this was encouraged by the settling of skilled Flemish immigrants in the district in the sixteenth century. The impurity of the local ores, however, rendered necessary the import of pure bar-iron from Spain and central Sweden for the finer work. Thus, over 400 years ago, began a branch of the steel industry which, largely owing to the "deposit" of skilled labour which has accumulated, has remained localised in this region. The only essential changes which have occurred are (1) the concentration of the more recently developed heavy steel industries in the Don valley between Sheffield and Rotherham, whilst the manufacture of cutlery and the lighter types of goods is more localised higher up in the Sheaf valley in the centre and south of Sheffield; and (2) the specialisation in the finest types of steel goods and in such articles as need a large amount of skilled labour expended upon a small quantity of raw material; this was a result of the inland position and the absence of local ore supplies.

The development of the steam engine and of iron and steel ships gave Sheffield new opportunities for producing fine steel forgings for the crankshafts and axles and, later, huge castings for turbine engines; the constant necessity for improvement in armour-plating and in guns and shells for destroying it opened up further fields;[2] the perfection of high-speed tool steels since 1900 has expanded the steel market still further; whilst the development of chrome-iron alloy, which produces stainless steel,[3] just before the First World War, and the subsequent use of this material not only in the cutlery trade but also for an ever-expanding list of products in the engineering industry, have insured that, despite its inland position, Sheffield's accumulation of plant and skill will continue to maintain the special branches of the steel industry for which the town is justly famed. The industry underwent a considerable expansion in productive capacity during 1914–1918, and a further and even greater stimulus was provided by the Second World War, so that the output in 1952 was two and

[1] For a brief history of the Sheffield steel industry, see Lord Aberconway, *Basic Industries of Great Britain*, Chapter III; also R. N. Rudmose Brown, "Sheffield: its rise and growth," *Geography*, XXI, 1936, 175–184.

[2] Several armour-plate firms, *e.g.* Brown, Cammell Laird, and Vickers, extended their interests and use their Sheffield products in their own shipyards.

[3] See Marshal and Newbould, *The History of Firths*, 1924. Stainless steel contains about 18 per cent. by weight of chromium and 8 per cent. nickel.

a half times greater than that of 1913. No pig-iron is made in Sheffield, and by far the most important raw material is scrap. In recent years about 60 per cent. of Sheffield's steel output has come from basic open-hearth furnaces, with about 20 per cent. from acid open-hearths and 20 per cent. from electric furnaces. Sheffield is the principal centre in Britain for electric steel and also for alloy steel. More than half the electric steel furnaces in the country are in Sheffield, and in 1952 the city's output from such furnaces was 477,000 tons out of a national total of 930,000 tons. In alloy-steel the dominance is similar, partly of course since about half of all the alloy-steel made is produced in electric furnaces. In 1952 Sheffield produced 744,000 tons of alloy steel out of a national total of 1,135,000 tons.

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CHAPTER XVII

IRON AND STEEL[1]—*(continued)*

THE IRON AND STEEL TRADE; THE SECONDARY INDUSTRIES (TIN-PLATE, SHIPBUILDING, ENGINEERING)

The Iron and Steel Trade

THE following table gives details of Iron and Steel imports for certain years. Between 1913 and 1949, the years have been selected to show the fluctuation caused by the booms and slumps of the trade cycle.

IRON AND STEEL IMPORTS BY VARIETIES AND COUNTRIES
(Thousand Tons)

	Items	1913	1921	1929	1933	1937	1949	1950
Varieties	Blooms and Billets	514	178	579	230	435	301	161
	Sheet and Tinplate Bars	345	101	419	85	151	49	23
	Steel Bars, Angles, and Shapes	134	86	380	187	72	39	8
	Plates and Sheets	169	126	188	36	49	52	93
	Iron Bars, Rods, and Angles	200	128	186	15	25	—	—
	Hoops and Strips	72	32	174	79	72	30	6
	Girders and Beams	109	36	142	77	71	27	13
	Wire Rods	95	25	125	42	97	102	66
	Pig-iron	185	674	117	93	644	262	195
	Other Varieties	408	254	507	127	423	391	192
	Total	2,231	1,640	2,817	971	2,039	1,253	757
Country of Consignment	Belgium	583	847	1652	468	528	336	95
	United States	154	138	70	2	315	243	62
	France	37	249	308	113	316	207	301
	Luxembourg	*	*	68	57	134	164	42
	Netherlands	7	31	103	11	28	95	46
	Canada	*	19	4	*	164	64	39
	Germany	1,198	156	459	55	133	25	71
	Sweden	209	66	74	23	105	16	14
	Other Countries	43	134	79	242	316	103	87
	Total	2,231	1,640	2,817	971	2,039	1,253	757

* Not available.

It will be observed that much of the import is of "raw" or "semi-finished" materials, destined (pig, blooms, and billets) for re-melting

[1] By S. H. Beaver.

and processing, or (sheets, plates, and rods) for further fabrication. South Wales and Scottish ports take much of this imported material —naturally enough in view of the fact that the steel industry of those areas has been and still is in large measure divorced from iron smelting. The post-war expansion of British output seems to be reducing the quantity of imports, and our nearest Continental neighbours are taking an increasing share of the trade.

In the next table exports are similarly enumerated:

IRON AND STEEL EXPORTS BY VARIETIES AND COUNTRIES
(Thousand Tons)

	Items	1913	1921	1929	1933	1937	1949	1950
Varieties	Plates and Sheets	204	179	479	213	387	368	471
	Pig-iron	945	103	456	108	153	10	35
	Tubes and Pipes	400	135	454	273	376	496	510
	Railway Rails	500	177	327	56	148	120	175
	Steel Bars and Angles	251	107	316	107	231	332	522
	Miscellaneous	2,669	996	2,347	1,165	1,314	1,150	1,468
	Total	4,969	1,697	4,379	1,922	2,609	2,476	3,181
Country of Destination	Australia	567	149	406	120	149	198	462
	South Africa	261	93	293	170	304	176	191
	Iran	4	*	*	*	70	163	101
	India, Pakistan, and Ceylon	896	435	569	187	258	152	253
	New Zealand	154	61	138	54	122	122	179
	Netherlands	146	60	73	43	105	111	78
	British East Africa	19	*	46	7	21	91	96
	British West Africa	46	*	35	18	68	89	95
	Argentina	358	98	341	110	192	79	66
	Finland	*	*	12	18	30	79	78
	Canada	187	18	136	123	169	79	242
	Irish Republic (Eire)	*	*	89	33	65	70	101
	Other Countries	2,331	783	2,241	1,039	1,056	1,067	1,239
	Total	4,969	1,697	4,379	1,922	2,609	2,476	3,181

* Not available.

The 1913 figure has never since been reached, and probably, with world output rising rapidly, it never will be. Naturally enough, it is "finished" materials rather than "raw" iron and steel which are exported, and the increasing relative importance of tubes and pipes is a reflection partly of increased British output (notably from Corby) and partly of increased world demand for such products for use in oil transmission (note e.g. exports to Iran) and as tubular scaffolding. The destination of the exports shows a marked British Empire bias.

The Subsidiary Industries

The iron and steel industry obviously does not come to an end with the casting of steel ingots and the rolling of plates, bars and rails. Ingots, plates, and bars, although the finished products of the steel furnaces and mills are the raw materials of a number of other industries, which thus depend for their existence upon the output of the home steel industry or upon the imported material. Chief amongst these are shipbuilding, tin-plates, galvanised sheets, rails, tubes and pipes, constructional steelwork, castings (grates, etc.), wire and wire-products (netting, nails, etc.), and the various industries concerned with the manufacture of engines and machinery, and their constituent parts (cf. p. 355). To describe all of these would be impossible within the limits of a single chapter. We may, therefore, confine our attention to a few which are geographically most interesting. Three groups of industries will be studied:

(*a*) *The Tin-plate industry* and its allies, concerned with the covering of thin steel sheets with a coating or film of tin, zinc, or a mixture of tin and lead;

(*b*) *The Shipbuilding industry*, employing vast quantities of thick steel plates and girders; and

(*c*) The miscellaneous *Engineering industries*, depending for their raw materials upon foundry and forge iron from the blast furnaces and various forms of "semi-finished" steel from the mills.

A few simple geographical considerations will reveal certain definite localising factors in each of these groups. In the case of the tin-plate industry the bulkiest raw material is the steel plate which is to be coated; moreover, the tin has to be imported and the bulk of the produce is destined for export. It would seem, then, that a situation within one of the great seaboard steel-producing areas is most favourable. With shipbuilding we shall likewise expect to find a concentration mainly on those navigable estuaries or sheltered waters where the heavy iron and steel industry is also developed. The engineering industries, however, being concerned, generally speaking, with more valuable products, do not show the same tendency to be concentrated in close proximity to the parent industry; in fact, since the finished articles are usually more costly to transport than the raw materials of which they are composed, and since also the assembly of many different raw materials may be involved, we shall find that whilst many of the heavy engineering industries are concentrated upon the coalfields, in the case of the lighter types of engineering product the existence of a market for the goods, or the availability of good transport facilities, may exercise as much control over the location of the industry as do the sources of raw materials. Moreover, as with the primary iron and steel producers, there are many examples of engineering industries the location of which is

inexplicable in terms of present-day geographical and economic circumstances; we must often delve into the past to discover the location factors involved.

The Tin-plate and Allied Industries [1]

The art of giving a coating of some non-ferrous metal to a thin sheet of iron, in order to preserve it, was first practised in Bohemia about the fourteenth century. The metal used was tin and the sheets thus became known as "tin-plates." Subsequently the metals zinc and lead have also been employed for the same purpose, giving rise to the trade names "galvanised sheets" (coated with zinc) and "terne plates" (coated with a mixture of tin and lead).[2]

The first successful attempt to make tin-plate in Britain took place in 1720 at Pontypool, where a small iron industry already existed, and a good water supply was available for working the hammers which produced the flat plates, and for washing the plates before tinning. From this small beginning grew the great industry in South Wales. Its growth was aided by two subsequent events: first the invention in 1728 of a method of rolling plates (a much quicker and more efficient process than hammering), and secondly the substitution of coal for charcoal in the iron-smelting industry, permitting a much greater output. By the end of the eighteenth century a dozen works were producing tin-plate, and our imports of that commodity had been replaced by a growing export trade. The industry spread rapidly during the first half of the nineteenth century, especially in Monmouthshire, Glamorgan, Gloucestershire, and Staffordshire (the last two supplied with iron from the Forest of Dean). All the works, however, were subsidiary to pre-existing smelting works or forges which were favoured with abundant water supply.[3] The reasons for this early concentration in South Wales are not clear and decisive. Probably the chance selection of Pontypool as the first site for a tin-plate works prompted other ironworks in the neighbourhood to adopt this profitable sideline as an outlet for their iron at a time when the iron industry was not very flourishing; whilst the nearness of South Wales to the Cornish tin supplies may also have given that area an advantage. In addition, the momentum derived from an early start sufficed to maintain the supremacy of South Wales in the industry even when the methods of production were radically changed; whilst the inland position of Staffordshire, and the decline

[1] See J. H. Jones, *The Tin-plate Industry*; Rider and Trueman, *South Wales*, Chapter X; E. H. Brooke, *Monograph on the Tin-plate Works in Great Britain*, Swansea, 1932.

[2] The name "terne" reflects the fact that such plates are composed of *three* metals—iron, lead, and tin; but it may also be derived from the French *terne* =dull or tarnished, in view of the contrast with the brightness of tin-plate.

[3] See H. C. Darby, "Tin-plate Migration in the Vale of Neath," *Geography*, XV, 1929, 30–35.

of the iron industry in the Forest of Dean, prevented the rise of those areas in competition with South Wales.[1]

The last quarter of the nineteenth century witnessed vast changes in the nature and location of the tin-plate industry. By the early 'seventies Malayan tin had replaced the failing supplies from Cornwall, but this was of minor importance compared with the substitution of mild steel plates for wrought-iron plates. Acid open-hearth steel suitable for rolling into thin plates was first produced at the Landore works (near Swansea) in 1875, and the cheapness of steel compared with puddled iron, together with its greater suitability —steel plates having a smoother surface which absorbed less tin— soon resulted in its adoption in the tin-plate works. But acid steel could only be made from imported pig-iron, and in consequence steelworks, followed by tin-plate mills, began to be set up in the neighbourhood of the ports of Llanelly, Swansea, and Briton Ferry, and the "centre of gravity" of the tin-plate industry in the vales of Swansea and Neath migrated down-stream. Eight new steelworks, all associated with tin-plate mills, were erected between 1875 and 1900. Many of the older tin-plate works persisted, and still exist to-day; but the momentum possessed by an individual works—usually a small, comparatively inexpensive unit—was not great, and in consequence migration was not difficult. This "reshuffling" of the industry in the 'eighties, combined with the economic disaster produced by the American tariff of 1890, which almost cut off our chief market for tin-plate, naturally resulted in a period of depression, but the present century has witnessed a great expansion of the tin-plate trade, and a remarkable concentration of the industry upon the Swansea–Llanelly region.

Before considering the reasons for this development, let us further examine the nature and methods of the industry. Tin-plates have many uses, and the expansion of the petroleum industry, and of canning industries of all kinds, has naturally been accompanied by a great increase in the production of the tin-plates from which the containers are made. Tin-plate makes the only metal container capable of being hermetically sealed, and is perfectly safe for the canning of vegetables, fruit, fish, meat, and every other kind of perishable article. The chief consumers of tin-plate are the world's great fruit-growing and oil-producing regions, but the rapid development of canning and of oil-refining in Britain has rendered the home market of increasing importance, and the export trade has declined both relatively and absolutely (see table on p. 397).

A short résumé of the methods employed in the process of tin-plating may assist us in understanding the localisation of this

[1] In 1850 thirty-five tin-plate works existed, twenty-two of which were in South Wales. By 1875 the total had increased to seventy-seven, fifty-seven of which were in South Wales.

industry. Until the introduction at Ebbw Vale, and more recently at Margam, of the continuous hot-strip process, the first stage of tin-plate manufacture was (and still is in all the older works) as follows: a raw steel bar is first heated, rolled, doubled over on itself and re-rolled; after this process has been repeated the bar is thus reduced to a series of thin sheets (about $\frac{1}{100}$ of an inch to $\frac{1}{50}$ of an inch in thickness), which are then cut off to the required size and separated. The modern process, by a succession of rollers, produces the thin sheet in a continuous strip, which can be cut as required. The sheets, known now as "black plates," are then "pickled" in a bath of dilute sulphuric acid to remove the surface scum of oxide, and afterwards "annealed" (softened by heating in a furnace). The annealed plates are cooled and rolled to produce a smooth, shiny surface, and then annealed again to remove the hardness engendered by the cold rolling. A further acid pickling follows, to ensure that the plates are perfectly clean, and then each plate is passed successively through (*a*) a bath of zinc chloride (a flux designed to effect a final cleaning and dehydration, and to render the coating process easier and quicker); (*b*) a bath of pure molten tin, in which it receives a thin coating of that substance[1]; and (*c*) a bath of hot palm oil, which renders the film of tin uniform all over the plate. Large quantities of bran are used to remove all trace of oil from the plate,[2] which is finally allowed to cool and is then dusted and polished by cotton-covered rollers. The plates are then examined by experts for defects and are packed in elm or birchwood boxes for export. Electrolytic tinning of the plate is now replacing the older tin-bath method.

It will be apparent from this description that the needs of the tin-plate industry are as follows:

1. An abundant supply of steel of the required quality.
2. Pure bar-tin and refined palm oil, both of which must be imported from abroad.
3. A supply of fuel for the furnaces. Usually coal-fired furnaces are employed for heating the bars and for the annealing process, but anthracite gas is also used, especially for the tin-bath, with success since it gives a very even heat.
4. Electric current, conveniently obtained in the large new integrated works as a "by-product" of smelting and coke-making (cf. p. 354).
5. A large labour supply, the bulk of which must consist of skilled operatives.

The advantages of the South Wales area as a whole for the production of tin-plates, were fairly obvious from the start. We have further seen how the industry, following the construction of

[1] A sheet of tin plate is actually 98 per cent. steel and 2 per cent. tin.
[2] The bran, impregnated with rich oil after use, is an interesting by-product. It is sold for pig meal.

the coastal steel mills, migrated down-stream to Swansea and Llanelly. The subsequent dominance of this area in the industry needs further explanation, however, and the following reasons suggest themselves:

1. The coal supplies, including the valuable anthracite, are close at hand.

2. Rail communication is available via Shrewsbury, Brecon, or Gloucester with the Midlands, which provide the chief home market for tin-plate.

3. The Swansea area had a large available labour supply, already skilled in metallurgical industries (cf. Chapter XVIII); and the decline of copper smelting left much of this available for work in the tin-plate mills.

4. The copper refining and spelter industries of the same area produced as a by-product large quantities of sulphuric acid[1] which could be employed in the pickling processes in the tin-plate works.

5. The opening of the Prince of Wales Dock, Swansea, in 1882, and the establishment of shipping connections to all parts of the world, resulted in the bulk of the tin-plate trade being done through that port instead of through Liverpool, which had previously had far better world connections. Moreover, the founding of the Swansea Metal Exchange in 1887 tended further to focus attention upon the western region as the metallurgical centre of South Wales.

The distribution of tin-plate works in South Wales, before the advent of the vast new integrated works, is shown in Fig. 204. With the exception of a few near Newport, the largest and most important works were all located within a few miles of the coast in the Loughor, Tawe, and Neath valleys, or at the ports of Llanelly, Briton Ferry, Swansea, and Port Talbot.

Isolated centres of the tin-plate industry in Britain are Lydney, Gloucestershire, Stourport, Worcestershire—the last witnesses of the former prosperity of the trade in the Forest of Dean and around the Black Country—and Mold, Flintshire. The last-named centre owed its existence largely to its proximity to the port of Liverpool (which is the chief tin-smelting centre in the country), and to the Brymbo steelworks.

Less than one-half of the output is now exported, for the home market for tin-plate has greatly expanded. The tobacco industry requires large quantities, fruit and vegetable canning is employing larger amounts every year, and the petroleum industry absorbs a vast supply for cans and containers.

The exports of tin-plate were formerly almost world-wide in their

[1] During the roasting and smelting processes large quantities of sulphurous fumes are given off. They may be collected and chemically treated to yield sulphuric acid.

distribution and still, with the exception of the United States and Germany, there are relatively few important countries which do not, either regularly or occasionally, receive consignments from Britain.

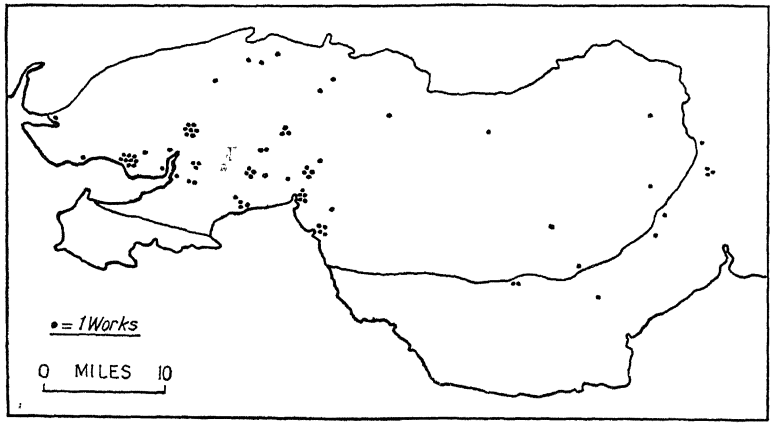


FIG. 204.—Tin-plate works in South Wales, 1932

Since the industry is undergoing considerable reorganisation as a result of the development o the large works at Ebbw Vale and Margam, no attempt has been made to bring this map up to date

Black plates (thin steel sheets without the coating of tin) form the basis of the enamelled hollow-ware industry, which has spread rapidly in South Staffordshire and in other parts of Britain. They

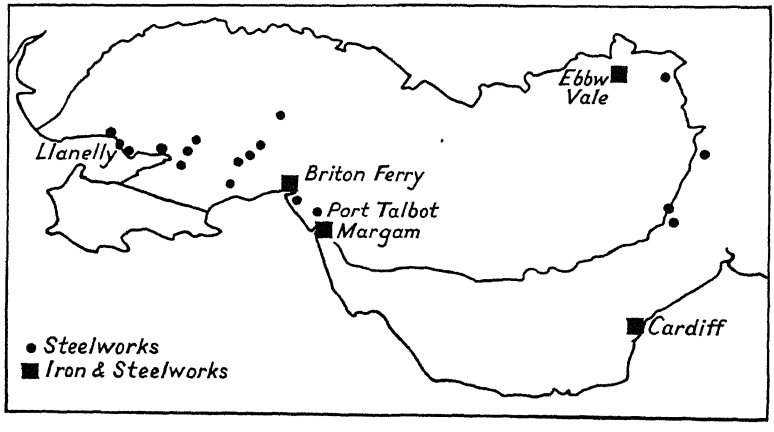


FIG. 205.—Steel works in South Wales, 1952

are also exported either for this purpose, or for conversion into tin-plates by certain countries which, although they can perform the tinning operation, cannot, or do not, produce the required quality of steel.

THE TIN-PLATE TRADE
(Thousand Tons)

	1913	1921	1929	1931	1936	1949	1950	1951	1952
Production (Tin, Terne, and Black Plates)	822	291	880	717	815	751	764		
Retained in Britain	328	50	269	317	445	545	513		
Exported	494	241	611	400	370	206	251	240	

DETAILS OF EXPORTS

Australia	29	18	57	37	64	72	65		
Canada	10	3	28	37	68	*	*		
British Malaya	17	12	27	14	10	10	8		
India, Pakistan, and Ceylon	52	28	23	8	4	14	17		
Argentina	19	4	27	17	39	16	33		
Brazil	14	2	22	18	3	3	3		
Japan	28	22	32	22	7	*	*		
China	15	8	20	16	12	*	*		
Netherlands	43	20	44	37	24	5	6		
Spain	12	9	28	19	1	*	*		
Portugal	14	4	18	19	7	*	*		
Belgium	13	8	23	10	9	*	*		
Norway	25	5	17	9	1	*	*		
Other Countries	103	98	245	137	109	86	119[2]		

* Under 3,000 tons.

[1] "Other Countries" not in the table include New Zealand (14), South Africa (8), Denmark (7), Iran (7), British East Africa (6), British West Africa (4).

[2] "Other Countries" not in the table include South Africa (19), New Zealand (17), Denmark (8), Iran (7), British West Africa (7), Irish Republic (5), British East Africa (4).

The manufacture of galvanised sheets is usually carried on by the firms which produce tin-plates, and several of the Welsh tin-plate works have associated sheet mills. When iron was the raw material employed Staffordshire was the chief centre, but with the change over to steel South Wales became the largest producer. The reasons for the concentration of the industry upon the Swansea district are the same as for tin-plate: the necessity for soft steel bars and the dependence on imported zinc and upon foreign markets for the produce. In addition, Swansea is the most important centre in the country for the smelting and refining of zinc (see Chapter XVIII). The chief centres of production in South Wales are in the immediate hinterland of Swansea, at Gorseinon, Pontardawe, and Morriston; at Llanelly; and at Pontymister, near Newport. At Bristol the spelter industry of Avonmouth has been a localising factor, and at Mold, Flintshire, the industry is allied to tin-plate manufacture, and was formerly favoured by the proximity of the Flintshire zinc mines. There are

also works at Shotton (alongside the great steelworks on Dee-side), and in the Glasgow area.

A coating of zinc protects the steel sheets from corrosion, and galvanised sheets, usually corrugated, are extensively employed for roofing and fencing in tropical countries, where they are far more durable than wood, being unaffected by damp and the ravages of insects. They are also employed to an increasing extent for cisterns

GALVANISED SHEET TRADE
(Thousand Tons)

	1913	1921	1929	1931	1936	1949	1950	1951	1952
Production	–	297	843	447	362	222	269		
Retained in Britain	–	85	131	159	137	129	156		
Exported	762	212	712	288	225	93	113	54	
DETAILS OF EXPORTS									
India, Pakistan, and Ceylon	244	58	251	62	45	*	*		
Australia	104	39	82	1	20	*	*		
S. Africa	40	13	64	38	23	10	7		
Canada	32	1	14	9	7	*	*		
Argentina	75	28	8	1	2	*	*		
Other Countries	269	73	293	177	118	83[1]	106[2]		

* Under 5,000 tons.

[1] "Other Countries" include British East Africa (8), British West Africa (8), New Zealand (8), British West Indies (5).

[2] "Other Countries" include New Zealand (9), British West Africa (8), British East Africa (7), British West Indies (6).

and tanks. The production of galvanised sheets in recent years has declined, and is now less than half that of tin-plates, but the proportion exported is slightly higher—about 40 per cent. The exports are somewhat more restricted in their distribution than is the case with tin-plates, and much of the tonnage is destined for Empire countries.

Terne plates, produced in a similar fashion by using a mixture of tin and lead instead of zinc, are cheaper than tin-plates and galvanised sheets. They are profitably employed for such purposes as roofing, the construction of motor-car bodies, the manufacture of drums for containing oil and paint, and in other trades where the presence of lead is not an objectionable quality. They also are a product of the tin-plate mills, and most of the output comes from the Swansea valley.

Shipbuilding

The shipbuilding industry, like the iron industry, has undergone revolutionary changes in its geographical distribution during the

last century and a half; and, as in the latter case, the changes have been essentially due to alterations in the nature, and thus the distribution, of the raw materials employed. The requirements of shipbuilding are two:

(1) A navigable waterway, as near to the sea as possible, in which the vessels can be launched.

(2) An easily available supply of the appropriate building materials.

When ships were constructed almost entirely of wood, the presence of fairly good timber supplies in many parts of Britain enabled the industry to be carried on at a large number of small estuaries and harbours all round the coasts, and the ease of import of timber permitted this to survive long after the local supplies were exhausted. The Thames below London and the Tyne were two of the most important centres, and such places as Inverness, Dundee, Whitby, Hull, Bristol, and Newport turned out many of those vessels—merchantmen, whalers, and ships of war—which helped to lay the foundations of the British Empire. The substitution, during the second half of the last century, of iron, and later steel, as the basis of the shipbuilding industry was naturally followed by the gradual decline of all those centres which were remote from the iron and steel-producing regions, and the increased importance of those estuaries, such as the Tyne, Tees, and Clyde, which were in close proximity to such regions.

Anything like a detailed history of the shipbuilding industry is impossible here[1]; we can only indicate in broad outline the general trend of events during the past century. The principal features may be outlined as follows:

1. *Raw Materials.*—Until about 1850 most ships were built of wood and were of quite small size—in 1815 the average size of the vessels in the British Merchant Fleet was 100 tons, and in 1855 the largest vessel in the world, the Cunard "Persia," was only 3,600 tons. The first iron vessel was launched in 1812, and the first iron vessel to cross the Atlantic (the "Sirius") did so in 1838, but even in 1850 only nine per cent. of the new tonnage constructed was of iron. By the 'seventies, however, iron was fast supplanting wood as the standard material, and in 1880 under four per cent. of the new tonnage was of wood. From this point, however, steel began to usurp the position which iron had gained and its success by reason of its greater tensile strength per unit of weight, was assured. By 1900 the new tonnage built of iron had fallen to nil.

The rise of the iron ship proved the salvation of the British shipbuilding industry, for our home timber supplies had been reduced

[1] A good short summary will be found in *Survey of Metal Industries*, pp. 363–369. Greater detail is given in Pollock, *Shipbuilding Industry*, 1905.

almost to nothing, and the repeal of the Navigation Acts in 1849, by throwing open our commerce to the world's ships, would have put British building at the mercy of other countries, such as the U.S.A., where abundant timber was available near tide water. The advantageous situation of our coal and iron supplies, however, not only prevented any such catastrophe, but gave to the British industry a stimulus which has maintained its world supremacy ever since.

2. *Method of Propulsion.*—Steam was first used as a method of propelling a ship in 1788, and the steamer "Sirius" crossed the Atlantic in 1838. By 1850, however, sailing vessels still represented 95 per cent. of the total British tonnage, and not until the 'eighties did the sail tonnage begin to drop below the tonnage under steam, since when its decline has been very rapid. The earliest steamships were propelled by paddle wheels. After 1850, however, although many paddle steamers continued to be built, the screw propeller became the more general method. Great advances were made in the efficiency of the steam engines by the employment of the multiple expansion principle; but the greatest revolution came at the end of the century with the introduction in 1897, by Sir Charles Parsons, of Newcastle, of the steam turbine, which is now almost universal amongst fast steam vessels. Much has recently been done to develop the burning of oil by steamships instead of coal. Oil has, of course, the advantages of being less bulky, more easily stored, cleaner and quicker to load, and requiring less man power at the boilers. Great strides have been made also, within the last few decades, in the adaptation of the Diesel engine, consuming heavy oil, to marine propulsion, and the tonnage of motor ships launched annually in the United Kingdom is now twice that of steam driven vessels (see p. 401). In 1936 of a world total of over 65 million tons of shipping, coal-fired steamers represented 32 million tons, oil-fired steamers 20 million tons, and motor-driven vessels just over 12 million tons. By 1950, the world total had risen to 85 million tons, of which coal-fired steamers represented only 16 million, oil-fired steamers 47 million, and motor-ships 21 million tons. In 1952, only 15 per cent. of the world's shipping was using coal, as against 45 per cent. in 1939 and 97 per cent. in 1914. In the same year, for the first time since the introduction of steam, not a single coal-fired ship was launched from British yards. The consequences for the British coal trade and tramp shipping of this wholesale abandonment of coal have been profound.

3. *New types of Vessel.*—The development of the giant passenger liner and of the large mixed traffic vessel have added new problems for the shipbuilders to solve, and the development of specialised traffic has been accompanied by great advances in the technique of marine construction. The conditions which control the design

and size of a ship are many and complicated. The type of work which the vessel is to perform plays the greatest part, but in addition the physical conditions of the ports of call (such as harbour and dock dimensions and depths), and of any ship canals which may be used, the possibilities of obtaining a traffic which will ensure a return on the initial outlay and, lastly, the numerous regulations of Lloyd's Register or any equivalent classification society, must be taken into account. In the last connection the method of calculating "net tonnage" for the purpose of port and canal dues is often of great importance in affecting details of the ship's construction. We may divide the Merchant Marine into three major classes: (*a*) the cargo ship; (*b*) the passenger liner; (*c*) the vessel designed to carry both passengers and cargo. Important factors which affect the design are:

1. In passenger vessels the "cargo" of people occupies a large amount of space above the water line, although it is of no great weight. On the other hand, cargo ships have to carry great weights of material which must, for the sake of stability and protection from the sea, be carried in the holds below the water line.

2. Passenger vessels, in the interests of safety, must have numerous water-tight compartments below in order to retain the buoyancy of the ship should any part of the hull be "holed."

3. Whereas the total weight of a passenger liner is not very different empty from loaded, the weight of a cargo vessel may be increased by several thousand tons on loading, and in consequence special care must be taken over the design of the framework in order to minimise the disturbing effects of varying displacement.

In addition to these major types, certain other classes of vessel have been developed for special kinds of traffic. Specially designed vessels for carrying coal, ores, and grain in bulk were early developed.

UNITED KINGDOM SHIPBUILDING: TONNAGE LAUNCHED (EXCLUDING WARSHIPS)
(Thousand Tons)

Class	1913	1921	1929	1933	1937	1942[1]	1949	1950	1951	1952
Steamers:										
Coal fired .	1,911	*	750	78	307	*	23	31	12	0
Oil fired . .	0	*	306	5	220	*	413	497	369	440
Total Steamers	1,911	1,430	1,056	83	527	814	436	528	381	440
Motor Ships .	8	102	464	48	388	448	832	797	960	854
Barges, etc. . .	13	6	3	2	5	13	0	0	0	8
Total . . .	1,932	1,538	1,523	133	921	1,276	1,267	1,325	1,341	1,302
Tankers . . .	238	251	175	3	144	312	434	614	834	370

[1] War peak year.

Total tonnage launched in 1953 1,344,115 tons

* Not available.

More recently, the progress of refrigeration in merchant vessels has produced whole fleets of ships designed to carry cargoes of frozen or chilled meat, fruit or dairy produce,[1] with remarkable results in the distribution of the world's food supplies. Another special design is the "tanker" for carrying oil in bulk—a design which has played a considerable part in the demand for new tonnage in recent years (see table), with the increasing use of oil in transport and industry. The most modern tankers can carry as much as 25,000 tons of oil, which can be loaded and discharged by pipe-line in a few hours. In 1952 oil-tankers represented no less than 22 per cent. of the world's mercantile marine.

Geographical Distribution of Shipbuilding

The increase in the size of ships and in the bulk of the machinery and component parts of which they are built has greatly accentuated the localisation of the shipbuilding industry upon the largest estuaries adjacent to the steel-producing regions. Only deep navigable waterways like the Tyne, the (improved) Clyde and Belfast Lough can cope with the giant ocean liners of to-day, and the cost of transporting the massive plates, girders, and machinery which are required for these vessels renders their erection far from the source of the materials an uneconomic proposition.

The great shipbuilding regions of the British Isles are five in number: (1) North-East Coast; (2) Clyde; (3) Belfast; (4) Birkenhead; (5) Barrow. In 1948 there were some 234,000 people employed in shipyards (i.e. new construction and repair work) in Great Britain. Of these 56,000 were in Scotland, 47,000 on the North-East Coast, 31,000 in the North-Western Region (including Barrow and Merseyside), 28,000 in London and the South-Eastern Region (mainly ship-repairing on the Thames and naval work on the Medway), 28,000 in the Southern Region (mainly repair work at Southampton and naval construction at Portsmouth), and 18,000 in the South-Western Region (mainly naval work at Devonport).

The following table shows the tonnage of new merchant shipping launched at the various centres. Ship repairing and naval construction will be referred to in more detail below, p. 406.

(1) *The North-East Coast Region* includes the lower Tyne, where the chief centres are South Shields, Newcastle, Hebburn, Wallsend, Jarrow, and Willington; the lower Wear, centred upon Sunderland; and the lower Tees and adjacent coast, where the principal centres are West Hartlepool, Middlesbrough, and Stockton. It was estimated in 1928[2] that between one-sixth and one-seventh of the total

[1] The first cargo of frozen meat arrived in England from Australia in 1879; the first cargo of fruit from Jamaica in 1896; and the first load of dairy produce from Australia in 1911.

[2] H. A. Mess, *Industrial Tyneside*, 1928.

SHIPBUILDING: TONNAGE LAUNCHED[1] (EXCLUDING WARSHIPS)
Gross Tonnage (Thousands)

Area	1913	1921	1929	1933	1937	1949	1950	1951	1952
Clyde	685	505	532	49	337	434	438	428	448
Tyne	366	355	272	11	102	218	206	243	201
Wear	300	144	245	12	156	181	191	197	171
Tees	308	164	92	15	83	132	141	176	168
Belfast	129	93	144	14	74	97	131	118	130
Mersey	34	51	55	3	34	57	67	67	68
Dundee	18	17	17	7	21	21	19	30	24
Humber	49	31	27	8	16	19	20	15	14
Barrow	2	64	20	0	48	36	60	20	31
Leith	19	17	32	7	36	35	30	28	29
Other Districts	22	97	87	7	14	37	22	19	18
Total	1,932	1,538	1,523	133	921	1,267	1,325	1,341	1,302

[1] Only vessels of 100 tons and over are included in this table and the previous one (*Lloyd's Register of Shipbuilding*—annual summaries).

employable population of Tyneside depended for its livelihood upon the shipbuilding industry. Although vessels of all kinds are built here, there has been a definite tendency to concentrate upon warships, small "tramp" steamers, and especially colliers,[1] and more recently oil tankers. A notable exception, however, was the old "Mauretania," launched at Wallsend in 1907. The most famous firms on the Tyne are Swan Hunter & Wigham Richardson and Vickers-Armstrongs; from the yards of the latter the warship H.M.S. "Nelson" was launched in 1925.

The north-east coast region has declined slightly from the dominating position which it held thirty years ago. At the beginning of the century 50 per cent. of the British output of ships (or nearly one-third of the whole world's output) was being constructed here. Before the great depression of 1931–1933 this percentage had fallen to between 40 and 45 per cent.; it fell still lower in the mid-1930s, but has recovered since the war to an average of 42 per cent. in 1950–1952. This relative decline is largely due to the increase of Clyde, which is now without any doubt the greatest shipbuilding region in the world. There has been little change in the relative importance of the three rivers. The percentage of the total north-east coast launched by the areas named in 1900–1903 was as follows [2]: Tyne 36, Wear 32, Tees 17, Hartlepool 15. Hartlepool and the Tees suffered more severely during the great depression, but the figures for 1950–1952 do not differ markedly from those of half a century earlier: Tyne 39 per cent., Wear 33, Tees with Hartlepool 29.

[1] This is a heritage of the days of wooden ships, when the Tyne specialised in building colliers for the export of its "sea-cole" to London and elsewhere.

[2] *Industrial Survey: North-east Coast Area*, p. 229. (H.M.S.O. 1932.)

(2) *The Clyde* was never as important as the Tyne in the days of sailing ships. Its rise is more recent and really dates from 1812, when Bell's "Comet" was launched by John Wood at Port Glasgow. It was not an ideal waterway for shipping—at the end of the eighteenth century no boats drawing more than five feet could reach Glasgow; much of it is even now comparatively shallow, and only by persistent dredging has it been improved and maintained.[1] Over 20 shipbuilding firms are situated along a 20-mile stretch of the river below Glasgow. A characteristic feature is the great variety of the work undertaken; but the speciality is perhaps the large passenger liner for transatlantic or other fast ocean services. The famous Cunarders "Aquitania" and "Lusitania," and more recently, the "Queen Mary" and "Queen Elizabeth," were built by John Brown & Co. of Clydebank. Naval construction is also important, and among the many ships of war turned out by Clydeside yards is the battleship "Vanguard." Of the many well-known firms the most famous are John Brown & Co., who did so much in co-operation with the Cunard Line to develop the turbine engine, Harland and Wolff, the Belfast company, owning some 300 acres of shipyards on the Clyde, William Denny of Dumbarton, builders of many cross-channel steamers, and the Fairfield Company of Govan. Their yards are probably the best equipped in the world, and are constantly being improved by the employment of labour-saving machinery.

The north-east coast and the Clyde together have been responsible, since the First World War, for about 75 per cent. of the British output of ships. The other areas are much smaller, both in areal extent, and in output.

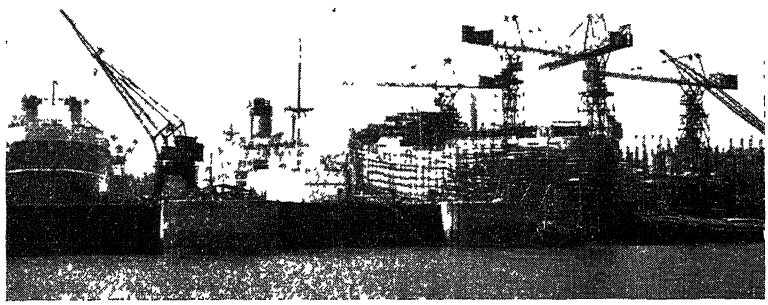
(3) *Belfast.*—Although not backed by a great iron and steel producing region, the head of Belfast Lough, by the estuary of the Lagan, has remained an important shipbuilding centre by reason of the ease of import of the fuel and raw materials required. Both western Scotland and western Cumberland are capable of supplying Belfast with fuel and with steel, and the short sea journey involved does not add greatly to the cost of these materials. Belfast-built liners and cargo vessels are to be found on most of the world's principal shipping routes. Messrs. Harland and Wolff own 220 acres of shipyards and engineering shops; many of the "White Star" liners were launched from their yards, and Belfast engineers have materially aided the development of the Diesel engine for nautical purposes.

(4) *Birkenhead.*—At Tranmere, on the southern side of Birkenhead, are the large yards of Cammell, Laird & Co., builders of warships, cargo ships, tankers and passenger liners.

[1] For 12 miles below Glasgow the Clyde is "as artificial as the Suez Canal."

(5) *Barrow.*—Shipbuilding was not important here until the local hæmatite ores came to be used in large quantities for steel-making. The first vessel was launched in 1873. The greater part of the industry is now under the control of Messrs. Vickers. Both naval and merchant vessels have been built, and in recent years Barrow has shared the pick of the new liner tonnage with the Clyde and Belfast, but the speciality, for which no geographical reason can be given, is the construction of submarines. Most of the British submarines, other than those launched in the Royal Dockyards, have been built at Barrow.

A number of other ports have small shipbuilding industries, but the vessels constructed are mostly small. The Humber region



[*Photo · S. H. Beaver*

FIG. 206.—Birkenhead Shipyards

On the right, new construction; in the middle, graving dock for repairs with R.M.S. Gothic, on the left, fitting out basin with a whaler

offers a remarkable example of an industry carried on solely as the result of momentum gathered in past years. Always an important fishing centre, this estuary naturally developed the building of all kinds of fishing boats—and the ease of access, by canal and rail, to the Yorkshire coalfield, and by sea to the great iron and steel-works of the north-east coast, has resulted in a continuation of the industry. Beverley, on the river Hull, Selby on the Ouse, and to a smaller extent, Goole and Thorne, are engaged in assembling trawlers and drifters, for which various firms in Hull build the engines, and the Humber retains its position in the front rank of fishing craft construction centres.

Aberdeen, at the beginning of the last century, was the chief shipbuilding port in all Scotland, and later on in the 'fifties and 'sixties many famous "tea clippers" were launched from its yards for

service between Britain and China. Subsequently, however, it has come to specialise in vessels for its own particular trade, i.e. trawlers, whalers, and other fishing craft.

Dundee, Leith, and Burntisland build cargo ships, and in the south of England, Southampton and Cowes specialise in yachts, motor boats, and the smaller types of naval craft.

The Thames deserves a little further comment.[1] For a long period London was one of the chief centres of British shipbuilding. The Blackwall yard, where the Orient Line had its origin, was founded in 1612, and a number of famous ships, including the "Warrior" (the first ironclad, built at Canning Town 1859), and the "Great Eastern" (built at Millwall in 1855), have been launched from Thames-side yards. During the Victorian period some of the most prosperous firms in the country were located here; but the distance from supplies of fuel and steel has driven them all either out of business or to other localities, and all that remains is the extensive repair service (*vide infra*). The surprising thing is that the industry managed to overcome the economic difficulties involved in distance from the steelworks for so long a period: the battleship "Thunderer," the last big vessel to be launched, was only completed in 1911.

Attention must finally be called to the shipbuilding activities of the Royal Dockyards. Although a considerable proportion of the naval requirements is ordered from public companies, a good deal of warship construction, amounting to nearly a half of the total, is carried out at Devonport, Chatham, and Portsmouth. All these places occupy heavily fortified situations where large expanses of tidal water are available for the "housing" of the British fleet. In many cases only the hulls of the new vessels are erected at the dockyard, the machinery being supplied by public firms of marine engineers.

Ship Repairing

In addition to the actual building of new ships, the repairing and overhauling of existing vessels is an industry of considerable importance. In its distribution, however, this industry differs considerably from shipbuilding. The chief necessity is a dry dock or some other means of raising the ship out of the water so that access to the hull may be obtained (see Fig. 207). It should be remembered, however, that many repairs may be effected without this preliminary procedure and that ordinary building yards may be used for repair work. Since it is obviously most economical to repair a ship on the termination of a voyage, during which the need for repair becomes apparent, the great ports of the country, as well as the shipbuilding areas, will share in the repairing industry;

[1] See Aberconway, *Basic Industries of Great Britain*, pp. 326–329.

for the amount of material necessary to effect the repairs will not be large and may be of very diverse nature.

Whilst the Tyne, as judged by the number of dry docks, etc., dominates the industry, dealing with all classes of cargo ships, liners, and tankers, the ports of London, Southampton, and Liverpool have extensive facilities, largely controlled by the great shipbuilding firms,[1] for the repair of the large liners and other vessels which visit them. The Clyde and Belfast are not nearly as important for repairing as for building—although more repairing is done on the Clyde than is suggested by Fig. 207, many building yards, when not engaged in new construction, being used for this type of work.

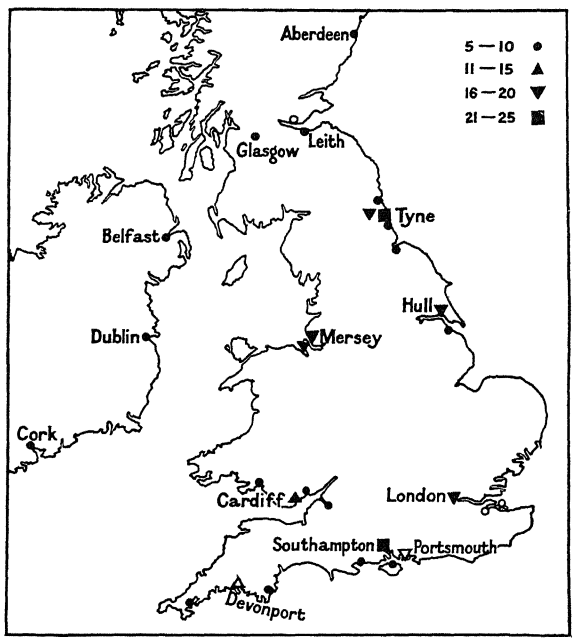


FIG. 207.—Facilities for ship-repairing in Britain—number of dry docks and slipways, 1951

The symbols in outline are naval dockyards. In addition to the ports shown on the map, forty-nine other ports have ship-repairing facilities

Marine Engineering

Although the chief new materials necessary for the shipbuilding industry are steel plates and girders, castings, forgings, tubes and pipes, i.e. the "heavy" products of the iron and steel works, numerous other items enter into the construction of a ship. A large amount of finished machinery such as winches and pumps is required, and large supplies of furnishing materials, joinery, paint, rope, and

[1] Harland and Wolff, for example, own extensive yards at Liverpool and Southampton and control the repair yards of the Port of London Authority.

nautical instruments are also necessary. Many subsidiary industries are thus involved.[1] Chief of these, however, is marine engineering —the construction of the boilers, turbines, and driving gear for all kinds of vessels. The marine engineering industry, dealing as it does in very bulky, though valuable, pieces of machinery, must of necessity be located in close proximity to the shipyards. In many cases the shipbuilders control their own marine engineering works[2]; and some of them even control the output of the steel which they

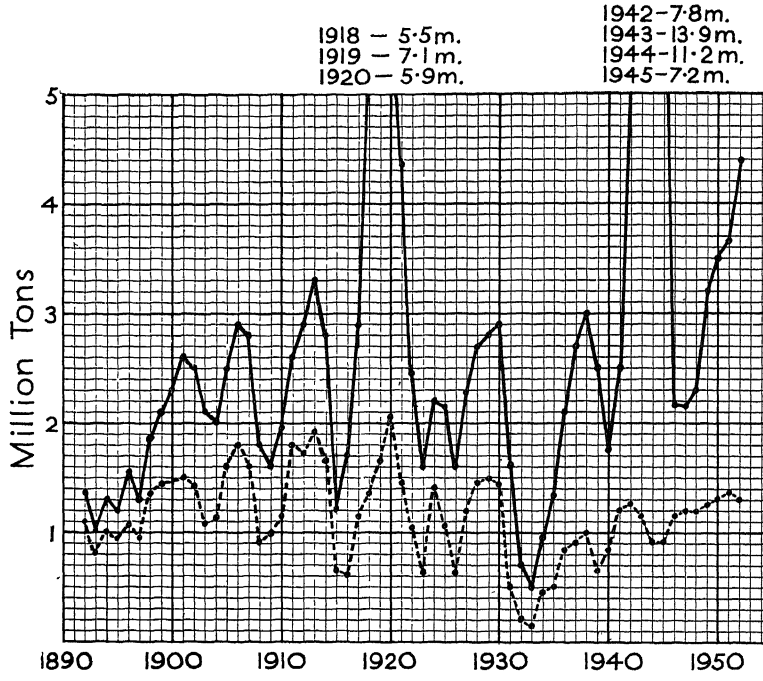


FIG. 208.—Shipbuilding in Britain and the World, 1892–1952

Graph showing tonnage launched (excluding warships and sailing vessels in the world (solid line) and Britain (dotted line)

employ. The chief centres of the industry are the Clyde, the world's greatest producer, where over 20 firms are engaged, and the north-east coast, where the most important firm, independent of the ship-building companies, is Parsons Marine Steam Turbine Co., on the Tyne. Employment in the marine engineering industry recorded by the Census of Production, 1948, amounted to 54,000, of which

[1] In 1930 (Census of Production) "ships' and boats' fittings" to the value of £44 million were employed—a sum not far short of the value of all the new construction and repair work done during the same year (£56 million).

[2] Harland and Wolff, for example, have shipyards at Govan, a foundry in Glasgow, diesel engine works at Finnieston and engineering works at Scotstoun.

over 21,000 were in Scotland and nearly 18,000 on the north-east coast.

The shipbuilding industry has been described as a "trade barometer," as it reflects, perhaps more faithfully than any other trade, the general state of the world's commercial activity. But it also reflects in a very remarkable way the incidence of wars, as Fig. 208 shows. At the same time it is the key to the prosperity, or otherwise, of a large number of subsidiary industries. Probably a third of the steel produced in Britain formerly went towards the building of ships, but so many other trades are involved that even a small slackening of the demand for new ships is immediately followed by a depression, the repercussions of which are felt throughout the country. The shipyards suffer most, however. The iron and steel works may have other products, such as boiler plates, girders, and rails, to which they can turn their attention, and the engineering shops may obtain orders for other types of machinery, but a shipyard must build ships or nothing.

The following table lists the output of the world's chief shipbuilding countries in certain selected years, the selection emphasising the booms and depressions. Complete figures for the war peak year, 1943, are not available, but the world total in that year reached the staggering figure of 13,885,000 tons, largely owing to the enormous tonnage launched in the U.S.A. In that same year the British output represented a mere 8 per cent. of the world total.

WORLD'S SHIPBUILDING (EXCLUDING WARSHIPS)
Gross Tonnage (Thousands)

Country	1913	1919	1926	1930	1933	1937	1949	1952
United Kingdom	1,932	1,620	639	1,478	133	921	1,267	1,302
Germany	465	*	180	245	42	435	*	520
France	176	32	121	101	34	26	155	212
Netherlands	104	137	94	153	36	183	169	296
Italy	40	83	220	87	17	22	99	132
U.S.A.	276	4,075	150	247	11	239	633	467
Japan	64	612	52	151	74	451	148	608
Other Countries	265	585	218	427	141	433	661	858
Total	3,332	7,144	1,674	2,889	489	2,710	3,132	4,395
Per cent. by U.K.	58	23	38	51	27	34	40	30

* Figures not available

Engineering[1]

The geographical principles underlying the distribution of the engineering industries have already been touched upon (p. 391).

[1] The term "engineering" is here used in a very wide sense, and is intended to cover not only engineering proper, i.e. the manufacture of engines and other machinery, but the whole range of products of which iron and steel form the basis.

It is probably true to say that there are few towns of any size in the country which have not either a foundry or some small factory making use of iron and steel.[1] This being so, a rough classification of the engineering towns is necessary in order that we may better comprehend the distribution of the industry. Engineering towns in Britain may be divided into two distinct types:

(*a*) Those in which the engineering industry is preserved by reason of the local supplies of coal and iron; e.g. the towns of the coalfields. The particular branch of engineering involved will depend primarily upon various local factors which we shall examine in detail later;

(*b*) Towns not situated on, or quite close to, the major coalfields and iron-producing centres. These towns may be further subdivided into two classes:

(*i*) Those in which the presence of the engineering industry is due to some definite local demand for certain types of iron products. Under this heading come most of the engineering centres of eastern England, where the manufacture of agricultural implements is of quite early origin.

(*ii*) Those in which the engineering industry is of much more recent growth and is due either to the situation of the town with regard to railways—as, for example, the locomotive building towns of Swindon and Ashford (Kent)—or to the presence of large and increasing agglomerations of population which can be drawn upon as a source of labour supply, e.g. Letchworth (Herts), Luton, and Slough.

This classification cannot be regarded as comprehensive or exhaustive, but it may serve as a guide in our study of the engineering industry of Britain. The chief engineering provinces are seven in number. They may be briefly summarised as follows:

(1) *Manchester and South Lancashire.*—Textile machinery, constructional engineering, engines and locomotives, and electrical apparatus.

(2) *Yorkshire, Nottinghamshire and Derbyshire Coalfield.*—Textile machinery (West Yorkshire), heavy engineering, locomotives; the special trades of Sheffield and the miscellaneous industries of Derbyshire and Nottinghamshire.

(3) *The North-east Coast.*—Marine engineering (*vide supra*), constructional engineering, locomotives.

(4) *The Scottish Lowlands.*—Marine engineering (*vide supra*), constructional engineering, heavy machinery, locomotives.

(5) *The Black Country and Birmingham.*—Heavy foundry and

[1] There are about 2,400 foundries in Britain; they absorb about 15 per cent. of the pig-iron output, and gave employment in 1948 to 120,000 people.

forge work, constructional engineering, miscellaneous trades of Birmingham.

(6) *The Smaller Midland Coalfields.*—Miscellaneous industries of North Staffordshire and Warwickshire.

(7) *South-eastern Great Britain.*—Scattered miscellaneous machinery industries and foundry products, especially agricultural and excavating machinery and locomotives.

Before we consider these provinces in greater detail certain rather specialised industries call for individual comment.

The manufacture of *textile machinery*, which gave employment to over 67,000 people in 1948, is dominant, as one would expect, in the great textile working regions of south-east Lancashire and the West Riding (see Fig. 209), the only other centres of any importance

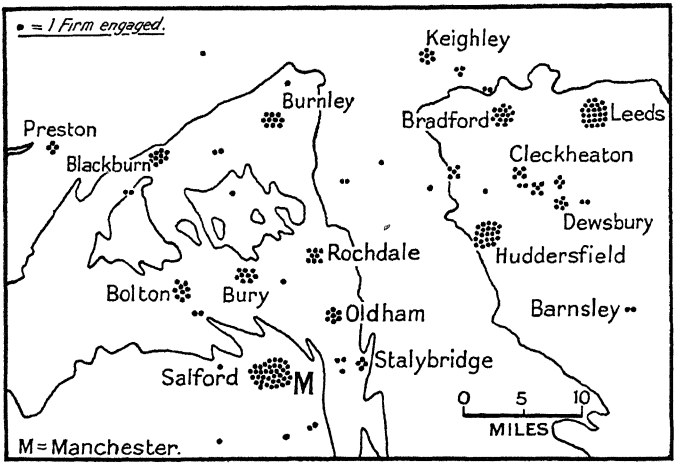


FIG. 209.—The textile-engineering industry of Lancashire and Yorkshire. Lines show boundaries of exposed Coal Measures

lying within the regions of minor specialised textile production (*vide infra*). At the 1948 Census of Production nearly two-thirds of the workers employed in the industry were in South Lancashire and just under one-fifth in the West Riding.[1] The industry has been located here on both sides of the southern Pennines ever since the first machines for working cotton were invented (i.e. since the end of the eighteenth century), and the growth of the textile industries, together with the presence of coal and the proximity of the iron and steel districts of Yorkshire and the Midlands, have given it such a momentum, that it easily retains the premier position, which it has always held,

[1] Total for Great Britain, 67,575; North-western Region, 39,257, E. & W. Ridings Region, 12,731.

supplying not only the local manufacturers, but also, until comparatively recently, most of the other textile industries of the world. The map shows that nearly every important town in the textile-manufacturing area of Lancashire and Yorkshire has one or more factories engaged in producing machinery for working cotton, wool, or artificial silk. Although the Lancashire towns confine themselves mainly to cotton-manufacturing machinery, and the West Riding towns to woollen and worsted machinery, a few firms in the towns where the two regions approach most closely (e.g. Huddersfield, Keighley, Rochdale, and Oldham) produce machinery for both industries; and firms making artificial silk machinery are to be found in both regions. Some of the larger firms turn out practically every machine which is used in the textile industries; others specialise in certain types of machine, or machines for special processes. The manufacture of machinery used in bleaching and dyeing, for example, is concentrated especially in the bleaching region of South-east Lancashire (Manchester and Bury) and in Huddersfield. Looms are made chiefly in the Lancashire weaving regions at Burnley and Blackburn, and in the West Riding at Bradford. It is impossible to give details, but two of the largest firms are deserving of special mention. Platt's of Oldham are the largest textile machinery factors in the world. They make all kinds of textile machinery, and in addition control their own machine-tool works. Dobson and Barlow of Bolton, established in 1790, claim to be the oldest firm of textile engineers in the world; they also control their own engine and tool factories.

The most important Lancashire centres of the industry are Manchester-Salford, Oldham, Bolton, Rochdale, Blackburn, Burnley, and Preston. On the Yorkshire side Leeds and Huddersfield dominate the industry, but Bradford and Keighley are also important, together with Halifax and a group of small towns lying between Dewsbury and Cleckheaton.

Much damage was done to the cotton section of this industry by the widespread depression of the cotton trades in all parts of the world—a consequence of overproduction. Great prosperity was enjoyed in Lancashire while the factories were building machinery for the growing cotton industries of Japan, China, and India, but the excess of productive capacity thus created caused a slump.[1] Foreign firms even bought second-hand machinery from Lancashire's closed mills. On the other hand, the growth of the artificial silk industry has created a demand for new types of textile machinery.

Of the other localities where textile machinery is made, the

[1] In the textile-machinery industry as a whole, employment declined from 70,000 in 1921 to 60,000 in 1924, and 48,000 at the Census of Production in 1930. The revival revealed by the 1948 Census of Production is largely due to the manufacture of machinery for working the newer textile fibres (see Chapter XXI)

chief are Nottingham and Leicester, which between them share the bulk of the trade in hosiery machinery. Nottingham, in addition, is supreme in the manufacture of lace-making machinery. Macclesfield occupies a similar position with regard to silk machinery; and Dundee makes most of the machinery used in the jute and hemp trades. A few other scattered centres in Scotland make various kinds of textile machinery, e.g. Hawick and Galashiels (woollen), Paisley and Glasgow (cotton). Belfast supplies machinery to the Irish linen industry. Much of the produce of the textile machinery industry, as suggested above, is destined for export.

EXPORTS OF TEXTILE MACHINERY
(Thousand Tons)

Country	1913	Average 1921–25	1929	1933	1937	1948
U.S.S.R. . . .	15·3	0·6	7·0	0·2	1·4	—
France	12·6	12·2	7·5	0·9	1·3	3·5
Belgium . . .	10·3	5·8	7·5	1·6	2·2	4·0
Germany . . .	13 9	2·7	5·1	1·6	2 5	—
Italy	2·4	4 1	4·3	1·3	0·3	0·5
China	3 3	9 4	10·6	2·5	2·3	2·8
Japan	19·7	15·0	14 4	1 0	0·7	—
India	50·3	49·1	38·2	24·9	25·9	23 0
Brazil	11 9	8·2	3·3	1·9	5·2	8·7
Other Countries .	38·3	28·3	78·6	20·6	30·5	17·5[1]
Total . . .	178·1	135·4	126·5	56·5	72·3	60·0

[1] Includes Egypt, Argentina, Australia, and Canada.

The 1913 export figure has never again been attained. The actual amounts exported to individual countries may fluctuate considerably from year to year—but it is still true that India is by far our best customer. The Far Eastern market has seriously declined, but our near European neighbours can still be relied upon to take textile machinery, whilst growing textile industries in other parts of the world are buying British machines.

The *Locomotive-building Industry* of Britain, although of long standing (some of the firms are over 100 years old), is distributed in an extraordinary fashion. Two factors contribute to this. First, locomotives can run on wheels under their own power, and so do not have to be built in the locality in which they are to work. This means that while we might expect, by reason of the bulk of the raw materials required, that the industry will be primarily located in those areas where iron and steel are produced, it will not surprise us to find building centres in places remote from such regions where other local factors may have given rise to the industry. Secondly, it was the policy of the principal British railway companies (and in this respect they were almost unique in the world) to build most of

their own engines and not to place extensive orders with engineering firms. This has resulted in the setting up of a locomotive industry in a number of places where, despite the distance from the raw materials, the railway companies concerned considered that the nodality of the site with regard to their particular system warranted the

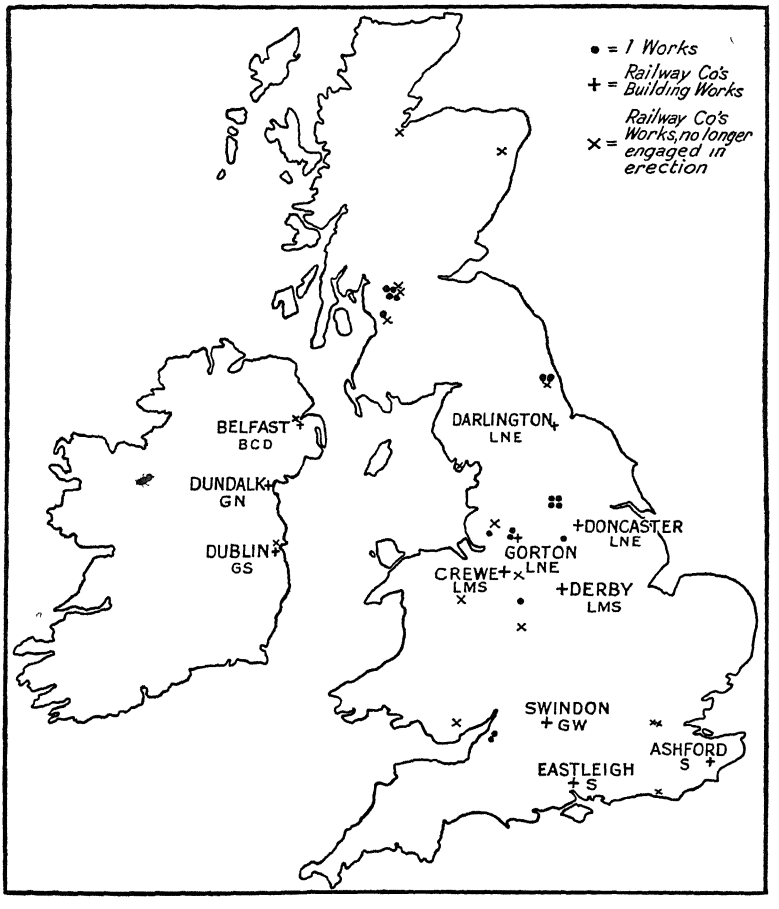


FIG. 210.—Map showing locomotive-building centres. Initials refer to the Railway Companies which existed before nationalisation

establishment of the works. Of the sixteen engineering companies which build locomotives, all but five are noticeably grouped about four nodes, each of which is in the heart of one of the engineering provinces, based upon the coalfields, which we have already mentioned (Fig. 210). The Glasgow-Kilmarnock area has four large works, three of which belong to the North British Locomotive Co.,

which is the largest concern of its kind in Europe. Two works are situated on Tyneside and three, of which the largest is that of Beyer, Peacock & Co., in the neighbourhood of Manchester. Another group of four have their headquarters in Leeds. The remaining works are situated at Darlington, Sheffield, Stafford, and two at Bristol. With the exception of the Bristol works, both of which build locomotives mainly for industrial purposes (works, docks, etc.) and not for ordinary railways, all these locomotive-building establishments are essential components of that great engineering industry of Britain which owes its development to the proximity of iron and coal. Many of the works formerly belonging to the railway companies, on the other hand, are situated at some distance from coal and iron, and the only explanation of their location is that they occupy nodal points on the railway system to which, before nationalisation, they belonged. Such are Crewe, Swindon, Oswestry, Eastleigh, Brighton, Ashford, and Stratford.[1] The works of the railways which served the industrial north, however, were naturally situated near to their sources of raw materials, as Doncaster, Derby, Darlington, Gorton, Horwich, Kilmarnock, and St. Rollox (Glasgow). The Irish centres, Dublin, Belfast, and Dundalk, are all ports on the east coast where the raw materials and fuel are most easily obtainable across the Irish Sea from England and Scotland.

After the amalgamation of the principal lines into four groups in 1923, the building of locomotives at many of the smaller and less well equipped works, e.g. Oswestry, Stoke, Barrow, Kilmarnock, Gateshead, and Cowlairs (Glasgow), was abandoned, their activities

EXPORT OF STEAM LOCOMOTIVES

(Tons)

Destination	1913	Average 1921–25	Average 1926–30	1932	1937	1946	1948	1950
Argentina .	11,571	2,686	7,814	91	114	–	3,114	
Brazil . .	1,279	158	1,079	–	2,151	748	827	
Egypt . .	224	–	2,254	27	1,976	–	835	
India, Pakistan, and Ceylon	14,810	16,622	14,037	672	1,571	14,142	515	
Australia . .	5,287	511	1,552	4	12	964	–	
S. Africa . .	3,878	2,382	1,868	62	798	9,711	9,039	
Brit. W. Africa	635	1,533	1,047	501	611	254	2,021	
Brit. E. Africa	1,094	825	1,338	–	–	474	–	
Other Countries	5,494	8,799	6,917	1,208	2,044	16,810	10,189	
Total .	47,121	33,461	38,495	3,483	9,277	43,103	26,540	
Number of Locomotives	?	662	681	169	147	437	280	

[1] The railway-created towns, Crewe and Swindon, will be more fully referred to in Chapter XXVII. See pp. 645–6.

being confined to the execution of repairs; and subsequently the process of rationalisation has still further reduced the number of works engaged in building, Horwich, St. Rollox, and Stratford having also ceased. As a result of this the remaining works are incapable, especially during the periods when heavy renewals are in progress, of turning out all the requirements. All the groups found it necessary to call upon public engineering companies for many new engines, and after nationalisation the process continued.

Many of our export markets have been lost by the setting up of locomotive-building industries in the countries which were formerly good customers. Of recent years the best markets have been India, Argentina, and the British territories in Africa.

The *Motor Industry*[1] is of much more recent growth. Daimler built his first car at Coventry in 1896. By 1907 the industry claimed 53,000 employees; in 1931 over 190,000 people were engaged in the construction of motor vehicles, and the total had risen to over half a million in 1950. The output rose rapidly from 95,000 vehicles in 1923 to 236,500 in 1950 and 416,900 in 1935, in which year the industry was the fourth largest in the country by value of output (or fifth by employment), and the United Kingdom was the world's second largest producer. In 1952 the output totalled 813,000 vehicles, consisting of 448,000 cars, 242,000 commercial vehicles, and 123,000 agricultural tractors. In the same year the export trade reached the large total of £324 m., representing no less than 12·7 per cent. of the total value of United Kingdom exports.

Motor vehicle construction is localised in but a few areas and localities, of which the West Midlands (including Birmingham, Wolverhampton, and Coventry) is still the most important, though its dominance is less than it was twenty years ago (in 1931, it had 40 per cent. of the workers, in 1950, only 24 per cent.). London now claims 20 per cent. of the workers, and Lancashire 10 per cent. The industry is divided into four branches—private cars, commercial vehicles, motor cycles, and agricultural tractors. The geographical influences to be borne in mind are these:

(1) A very wide range of industrial products is necessary for the building of motor vehicles. Of the iron and steel products, castings, drop-forgings, sheet metal, tubes, and wire may be mentioned, but a large number of other raw materials are required—woodwork, rubber for tyres, leather, glass, and much copper, brass, and aluminium, and more recently, plastics.

(2) Most of the work is skilled, hence a large labour supply already used to mechanical engineering is required.

[1] See G. C. Allen, *British Motor Industry*. London and Cambridge Economic Service. Special mem. No. 18. 1926. *Idem, British Industries*, Chapter VII. Longmans, Green & Co., 1933. *Survey of the Trade in Motor Vehicles*. Rept. Imp. Econ. Ctee. H.M.S.O. 1936

(3) The raw materials are so diverse and the final products, which can be transported under their own power, so valuable, that the location of raw-material supplies exercises little, if any, control over the location of the industry.

At Coventry, and to a less extent at Birmingham and Wolverhampton, the motor industry has developed out of an existing cycle industry, and its great progress in this area is essentially due to the great variety of trades already flourishing in the west Midlands, and to the huge "deposit" of labour well skilled in the multifarious engineering trades of Birmingham and its neighbourhood. Most of the iron and steel work required is made within the region (much of it from special Sheffield steels) and the Birmingham area is chief in the country for non-ferrous metals. Each of the three big towns has all branches of the industry represented, but Coventry deals especially in engine-building and in cars, Birmingham in motor-cycles, cars, and commercial vehicles, and Wolverhampton in commercial vehicles.

In the London area the presence of a huge population, the existence of numerous other engineering trades and the great demand for vehicles have contributed towards the rise of the motor industry. The Associated Equipment Co., which builds London's buses, is the chief establishment, whilst the Ford works is situated on Thames-side at Dagenham.

In south Lancashire, where the industry is centred upon Manchester and Leyland, the controls are similar—the presence of an engineering industry and a large skilled labour supply.

Of the outlying centres of the industry, Oxford easily leads. Here, at Cowley, from small beginnings, the enormous business of Viscount Nuffield has been built up—an organisation which has done much towards driving small foreign cars from British roads. Other notable centres are Derby (the home of the Rolls-Royce), Bristol, Huddersfield, Nottingham, and Luton.

The phenomenal rise of the motor industry as an exporter of major importance is shown in the following table, to which is appended a list of the principal receiving countries in two recent years.

EXPORT OF MOTOR VEHICLES

(Thousands)

	1913	1931	1935	1949	1950	1952
Motor Cars . . .	8	19	46	191	274	310
Tractors				182	86	128
Commercial Vehicles				38	70	107

EXPORT OF MOTOR VEHICLES
(Value in £ Thousands)

Countries	1949	1950
Australia	41,643	64,858
Canada	9,232	26,151
Sweden	2,877	11,451
New Zealand	6,137	10,192
S. Africa	9,415	8,883
India	4,662	6,477
U.S.A.	3,798	8,270
Brazil	4,298	5,158
Netherlands	3,330	5,225
Others	57,879	43,267
Total	143,271	189,932

Aircraft.—Closely allied to the motor industry is the aircraft industry, which in 1948 gave employment to 134,000 people in upwards of 200 factories. It is in fact less concentrated, and more widely scattered, than the motor industry, partly, no doubt, for strategic reasons and partly due to its need for airfields. Thus in 1948 the South-Western Region (dominated by Bristol) was the most important, with 28,000 workers, followed by the London and South-Eastern Region with 24,000. As with the motor industry, there has been a great increase in productivity since 1939, and a flourishing export trade has now been built up, as the following table shows:

EXPORTS OF MOTOR VEHICLES AND AIRCRAFT
(Value in £ Thousands)

	1913	1931	1935	1949	1950	1952
Aircraft	47	1,860	2,725	33,967	33,996	
Motor Vehicles	2,396	3,436	6,270	143,271	189,932	

Electrical Engineering.—With the development of domestic electricity and more recently of radio and television, the smaller electrical trades have expanded rapidly and have spread over many parts of the country; for the produce comprises for the most part small but valuable consumer goods, manufactured from a great variety of raw materials, and the industry can thus be carried on almost anywhere, the site depending more on the availability of labour and markets than upon railway facilities or the location of raw material supplies. The more prosperous cities and conurbations have attracted a great variety of such industries—radio, batteries, lighting accessories—which together in 1948 employed

235,000 people, but which would perhaps be more appropriately treated in the Chapter on Miscellaneous Manufactures since they depend to only an insignificant extent on iron and steel.

The heavy electrical trades, however (i.e. the construction of heavy electrical machinery and power-producing plant), which employ large quantities of iron and steel, often of special qualities, are more definitely localised. They employed in 1948 some 265,000 people (compared with only 149,000 in 1935), of which 74,000 were in the Midland Region, 58,000 in the North-Western Region (mainly south Lancashire) and 53,000 in London and the South-Eastern Region. In almost every case, the only important exception being Rugby, the industry is located in towns and cities where a flourishing machinery industry of one kind or another already existed; railway facilities have also played a part, for adequate means of transport are essential to an industry which imports much of its raw material (copper, mica, etc., from abroad and heavy steel castings, probably from Sheffield), and produces bulky and valuable goods. The metropolis of the industry is at Manchester, the home of the Metropolitan-Vickers Co., which produces power plant and electric locomotives of all kinds. At Rugby, the forerunners of the English Electric Co. set up their works in 1897, and a huge industry, increased by the advent of the British Thomson-Houston Co. in 1901, has resulted. Heavy machinery and turbo-electric plant are made here. These are the principal centres. Others of less importance are Coventry (radio apparatus and other plant), Preston (electric motors, locomotives, and formerly tramcars), Birmingham (electric motors and other plant), Hebburn-on-Tyne (switchgear), Loughborough (turbo-electric motors and railway equipment), and Stafford (generators and industrial equipment).

EXPORTS OF ELECTRICAL MACHINERY

(Thousand Tons)

Countries	1913	Average 1921–25	Average 1926–30	1933	1937	1946	1948	1950
U.S.S.R. . .	0·7	0·4	1 5	2·2	0·1	4·5	3·5	
Netherlands .	—	0·1	0 7	—	0·5	0·8	2·1	
China . . .	0·3	0·7	0·6	0·4	0·5	0·2	1·3	
Japan . . .	2·9	0·8	1·3	—	—	—	—	
India . . .	3·6	5·1	7·8	3·4	5·2	10·5	16·2	
S. Africa . .	1·6	2 6	4·2	4 4	10·7	6·7	11·3	
Australia . .	3·3	4·5	6·0	1·2	3·9	1·8	4·5	
New Zealand .	0·8	1·5	2·4	0·5	2·2	3·3	3·3	
Canada . .	2 0	0·4	2·0	0·3	1·4	1·4	1·7	
Argentina .	2·9	0 6	1·9	0 3	0·5	0·9	1·5	
Brazil . . .	1·3	0·7	0·9	0·2	0·3	0·9	1·3	
Other countries	7 4	6·7	10·2	4·7	9·2	28·8	54·4	
Total . .	26 9	24·1	39·5	17 6	34·5	59·8	101·1	

Cables.—The manufacture of cables and wiring for the transmission of electrical energy—an industry which represents probably a half of the total capital invested in electrical concerns in Britain, and which employs some 63,000 people,[1] is deserving of special mention. As an industry it represents a link between heavy electrical machinery and the non-ferrous metal trades (see Chapter XVIII). A moment's reflection upon the multiplicity of the uses of electric cables—for house wiring, post office and other telephones, railway signalling, power transmission, and submarine telegraphs—is sufficient to establish its importance in modern life.

Like the motor industry the manufacture of cables employs a great variety of raw materials: copper, aluminium, and steel wires, insulating materials in the form of rubber, oiled paper, and cambric, lead for sheathing, jute to form part of the protective covering, and timber for the rollers upon which the finished products are mounted for transport. Many of these items must be imported and a large part of the produce is destined for export, so that we shall expect to find the industry located near the large ports, especially in the vicinity of the non-ferrous metal industry (cf. Chapter XVIII). The banks of the Thames below London—as at Erith, Barking, and Northfleet—support nearly a half of the total industry, whilst a considerable proportion of the remainder is localised in the important non-ferrous metal district of south Lancashire, at Manchester, Prescot, and Liverpool; Glasgow is the centre of the trade in Scotland, and Newport in South Wales.

The cable industry is one of those few industries which did not suffer severely from the economic depression of the years 1931–1934, the progress of the grid scheme of the Central Electricity Board having provided it with an immense home market for overhead and underground cables; progress has been maintained since the Second World War, and the employment roll in 1948 was nearly twice that of 1932.

Engineering Provinces

We may now comment briefly upon the various engineering provinces mentioned above, noticing the geographical factors which have helped to influence their development and the present-day trends of their industries. (See table on p. 427.)

(1) *Manchester and South Lancashire.*—Manchester is the hub of one of the world's greatest engineering districts. In 1931 some 217,000 people in Lancashire and the adjoining part of Cheshire were employed in the various branches of the engineering industry, about 22,000 being engaged in the textile-machinery industry alone.

[1] Census of Production, 1948. Of this total 26,830 were in the North-western Region (i.e. South Lancashire) and 25,281 in London and the South-eastern Region.

Yet south Lancashire is not, and never has been, a great iron and steel-producing area. As we have seen (p. 348) the coalfield was almost devoid of Coal Measure ironstones so that no great smelting industry arose; and at the present time there is only one smelting works in the whole of the area—at Irlam, west of Manchester. The momentum acquired by the early textile-machinery industry, however, assisted by the availability of coal and the ease of access to supplies of iron and steel from Staffordshire and Yorkshire (by railway) and from Cumberland and Scotland (by sea), has been sufficient to attract a large number of heavy-engineering industries to the area, and the "deposit" of technical skill, which has been gradually accumulating since the eighteenth century, has found outlets in the designing and building of steam and other engines and all kinds of heavy machinery.

Three of the most important branches have already been noticed —textile machinery, electrical machinery, and locomotives. In addition, some 80 firms are engaged in building stationary steam engines and other power-producing plant (gas and oil engines, boilers, etc.). Since James Nasmyth (of Salford) invented the steam hammer, vast strides have been made in the efficiency of the machines which fashion the parts of the engines and machinery. The heavy machine-tool trade is the greatest in the country, and probably nine-tenths of the machines used in the manufacture of armaments, shafting, and heavy forgings in Sheffield are made in south Lancashire. The list of engineering products is almost unending. Mining, colliery, and saw-mill plant, and machinery for numerous food-preparing trades, wire ropes, cables, and chains, hydraulic machinery, and constructional steelwork are among the most important. After Manchester and its suburbs the chief engineering towns are Bolton, Preston, and Oldham.

(2) *The Yorkshire, Nottingham, and Derby Coalfield.*

(*a*) *The West Yorkshire Conurbation.*—The engineering industries of West Yorkshire as a whole employed, in 1931, over 111,000 people. The geographical bases of the industry are similar to those which are found in the case of South Lancashire, namely the early start in the manufacture of textile machinery and the ease of access to coal and iron. In contrast with Lancashire the importance of local iron manufacture—mainly south of Bradford—has been considerable, but the industry, famous for "Best Yorkshire" wrought iron, is now extinct. Within the area there is a tendency towards the segregation of the textile-machinery industry in the west—at Bradford, Keighley, Bingley, and Halifax—whilst locomotive manufacture and the heavy iron and steel trades are to be found mainly on the lower ground farther east, at Leeds, Huddersfield, and Wakefield. Apart from the textile machinery and locomotives already dealt with, the following engineering products may be

cited: railway rolling stock and the materials therefor (wheels and axles), tramway rails (probably 50 per cent. of all the tram rails in Britain have been rolled at Leeds),[1] machine tools, drilling and boring machinery, hydraulic apparatus and certain types of constructional steelwork (e.g. gasholders). All these trades employ iron and steel from Middlesbrough, Scunthorpe, and Sheffield.

(*b*) *South Yorkshire.*—The unique industries of Sheffield (cf. Chapter XVI, p. 387) are divisible into two groups: (*a*) cutlery and small articles,[2] e.g. hand tools, clock springs, and pen nibs; (*b*) the heavy steel trades. The latter include huge castings and forgings for ships and heavy machinery, armour plating, guns, and certain types of railway, tramway, and electrical apparatus where special hardness, strength or magnetic properties are required. Some of the names in the Sheffield steel industry are world famous: Firth's (stainless steel), Vickers (the Manchester electrical engineers and Barrow shipbuilders), Cammell Laird (the Birkenhead shipbuilders), John Brown (the Clyde shipbuilders) and Hadfield's (the pioneers of manganese steel) are amongst the best known.

Rotherham takes part in two types of Yorkshire industry, the special steel manufacture of Sheffield, and the wrought and cast iron trade which developed on the coalfield in the early days of iron smelting. Like Sheffield, it makes, at the Park Gate and other works, special steels and their products—heavy castings and forgings for marine engines and other machinery. Side by side with this have developed the railway rolling stock and constructional steelwork trades. Very different, and much older, however, are the wrought-iron industry and the manufacture of stoves and grates.[3]

(*c*) *Derbyshire and Nottinghamshire.*—The industries of this group, whilst owing their origin to the presence of coal and iron, are more allied by their miscellaneous character to the scattered engineering trades of south-eastern Britain. It is probably due to the towns themselves not forming a coherent whole, and to the absence of any vast industrial occupation, such as textiles or shipbuilding, which could generate a machinery industry. Typical of the area (apart from the locomotives and hosiery machinery already referred to) are the chains, castings and refrigerating machinery of Derby, the cycles of Nottingham, the tubes of Chesterfield, and the cast-iron pipes produced at the Stanton and Staveley ironworks.

(3) *The North-East Coast.*—The two characteristic engineering industries of this region are the building of marine and locomotive engines, located principally on Tyneside, and the production of ship plates, rails, and constructional steelwork, centred upon Teesmouth.

[1] Aberconway, *op. cit.*, 94.

[2] Employment in cutlery industry, 1948 (Census of Production), 13,046 in Great Britain, of which 8,776 in Yorkshire and 3,305 in the London Region.

[3] It is interesting to recall that the plates for the "Great Eastern" were rolled at Rotherham (cf. p. 406).

Marine engineering is a natural accompaniment of shipbuilding, and locomotive building is a kindred industry which here, as on the Clyde, has assumed large proportions (cf. pp. 408 and 414). The constructional steelwork (girders for bridges and buildings) produced by Dorman Long and other famous bridge builders of Teesmouth is a peculiarity the origin of which is less obvious. There are two factors to be borne in mind:

(*a*) The iron industry of Teesmouth began much later than those of the coalfields, in an area where there was no previous industrial development and no existing machinery industries.

(*b*) The coastal site favoured the growth of an industry which specialised in bulky, unwieldy products for which a large market existed abroad. Thus the heavy machinery industries never developed, and the principal products, apart from the export of iron and steel to other areas, have been shipbuilding steelwork, rails, and girders. Recent triumphs of Teesmouth are the steelwork of Sydney Harbour Bridge, of the Little Belt Bridge in Denmark, and of the Lower Zambezi bridge.

(4) *The Scottish Lowlands.*—The western portion of the Scottish lowlands, centring on Glasgow, but extending north-east to Falkirk and south-west to Kilmarnock, is a great engineering province for three reasons:

(1) There are excellent facilities for the production of iron and steel from local and imported materials.

(2) For a period in the 'thirties and 'forties of last century central Scotland was the most important iron-producing region in Britain, and consequently was a centre of attraction for many engineering industries.

(3) The shipbuilding industry naturally gave rise to a marine engineering industry, and the skill acquired in this branch could easily be applied to other branches of engineering.

The region thus partakes of the characteristics of both Manchester and Tyneside. In 1930 about 90,000 people were employed in the engineering trades.[1] The great marine-engineering industry of the Clyde, employing 20,000 people, has already been dealt with, and we have seen that Glasgow is the most important locomotive-building centre in the British Isles. The textile-machinery industry is present, though it bears no comparison with that of South Lancashire. One firm at Clydebank, however, employs 10,000 people in the manufacture of sewing machines. As a natural accompaniment to locomotive building, we have boiler making (e.g. Babcock and Wilcox), and the production of stationary steam engines and pumps.

[1] *Industrial Survey of South-west Scotland*, p. 63.

These trades, together with marine-engineering, have given rise to an extensive manufacture of machine tools, in which branch the Glasgow district seriously rivals the Manchester area. Glasgow leads the world in the production of machine-tools for the building of marine engines; and it is the chief centre in Britain for the production of mining equipment, such as coal-cutting machinery. Constructional engineering is another natural outlet for the steel of a seaboard region; and among the many firms engaged in this branch the most famous is that of Arrol & Co., the builders of the Forth, Tay, and Tower bridges. Other characteristic products of this province are steel tubes, hydraulic engineering machinery, sugar-making machinery (a result of Glasgow's former important trade with the West Indies), and various types of cast-iron articles such as stoves and grates, for which the Carron company, for example, is specially noted. The most recent introduction is heavy electrical engineering—a natural result, perhaps, of the development of hydro-electric power schemes in the Highlands.

(5) *The Black Country and Birmingham.*—The Black Country is the oldest of the great engineering provinces, and the origin of its iron and steel industry has already been discussed (Chapter XVI, p. 382). Even in the sixteenth century the manufacture of nails, knives, and locks was going on in the area,[1] and the momentum given by this early start, by the fortunate occurrence in juxtaposition of the raw materials of the iron industry, and by the steam-engine trade of Boulton and Watt in the last 20 years of the eighteenth century, enabled a vast engineering industry to be built up. Birmingham, not on the coalfield, quickly began to specialise in small valuable articles, whilst the heavier industries concentrated in the Black Country. The interior position of the region was originally a disadvantage, but the nodality which resulted from the construction of canals and railways meant that all districts could be equally well served, though shipbuilding and marine engineering could hardly be expected to develop.[2] As a result the dominant note of the engineering industry became *variety*. The decline of iron smelting has been accompanied by an even greater specialisation in all kinds of engineering industries based upon local steel produced from non-local ores and scrap. The localisation of many of these industries is not geographically explicable, being often almost accidental and due to the chance decision of a manufacturer of certain goods to set up his factory in a particular spot. Interesting local specialities, the origins of which are buried in history, are to be found at Willenhall (locks), Darlaston (nuts and bolts), Wednesbury (tubes),

[1] Leland's *Itinerary*, Vol. IV, fol. 186.

[2] It is interesting to recall, however, that one of the very earliest iron steamships—the "Aaron Manby" of 1822—was actually built at Tipton and sent in sections by canal to London for assembly and launching!

West Bromwich (coiled springs), Cradley Heath (chains), and Walsall (saddler's ironmongery).[1]

Only the outstanding products can here be indicated. The list is so extensive that any enumeration must omit many important ones. Amongst the principal *groups* of products, however, the smaller usually included under the term "hardware," the following seem to be characteristic: chains (especially for ships' anchors); locks and keys; nuts, bolts, and screws; steel tubes; iron castings of every description; stoves, grates, and fireirons (and their modern developments, gas and electric fires); constructional steelwork; railway rolling stock; and many kinds of steam and other engines and machinery. The iron hollow-ware (now frequently called in the trade "holloware") industry has been very largely replaced by the manufacture of similar articles in aluminium (see p. 448).[2]

The trades of Birmingham are of such bewildering variety that it is impossible to give an adequate selection. So many of them, moreover, involve the use of other metals than iron and steel that the discussion may best be deferred.

(6) *The Smaller Midland Coalfields, and adjacent areas.*

(*a*) *North Staffordshire.*—Most of the iron smelted in this region is sent away, either as pig-iron or as semi-finished steel, to other areas, notably South Lancashire and Dee-side.[3] There is a small engineering industry concerned chiefly with foundry products and with machinery for the local pottery industries in Stoke-on-Trent. But Stafford, largely by reason of its excellent rail facilities (for it is off the coalfield), has become an engineering centre of major importance, with locomotive-building, heavy electrical engineering, and reinforced concrete engineering. Uttoxeter, long famed as an agricultural market, produces farm machinery.

(*b*) *Warwickshire and Leicestershire.*—This group, like Derby and Nottinghamshire, has a number of miscellaneous iron and steel industries. Stoves and grates are again prominent, as at Leamington and Warwick (which also has motor-car assembly). Coventry has a vast trade in castings, forgings, and tools for its great motor, cycle, and aeroplane industries. Leicester makes, amongst other things, heating and ventilating plant, machinery for its own hosiery and boot and shoe trades, and stone-crushing apparatus (possibly a result of the proximity of the Charnwood quarries); and Rugby and Loughborough, as mentioned above, are important centres for the manufacture of all kinds of electrical apparatus and machinery.

[1] See British Association Handbook, "Birmingham and its Regional Setting," 1950, pp. 161–248.

[2] Employment in "Hardware and Holloware" industry, 1948 (Census of Production):—Great Britain, 175,297, of which 61,723 in Midland Region (i.e. mainly Birmingham and the Black Country).

[3] The Shelton iron and steel works at Stoke is linked, economically, with the Shotton steelworks.

(7) *South-eastern Great Britain.*—The scattered engineering industries of the region lying south-east of a line from the Humber to the Bristol Channel owe their origin in many cases to the agricultural implement manufacture, which arose at certain nodal points in this, the essentially arable part of Britain.[1] In other cases the industries have developed largely because (i) good railway facilities permitted easy access to sources of raw material; (ii) the local population provided at one and the same time a ready market for the articles produced and a source of labour supply. Of the towns where agricultural machinery formed the basis of the engineering industry, the most important are Lincoln, Gainsborough, Grantham, Thetford, Leiston, Ipswich, Colchester, and Rochester. In most cases the outlook has broadened, however, and other types of machinery are now more important than ploughs and reapers. Lincoln, for example, is probably the chief centre outside North America for the manufacture of excavating machinery: Ruston-Bucyrus draglines and face-shovels are used the world over. In addition, every type of road locomotive (steam rollers, traction engines, etc.) is made, together with a variety of agricultural machines and boilers and engine parts. Gainsborough makes dredges; Ipswich makes cranes, excavators, railway material, and electric road vehicles; Colchester deals in boilers and gas engines; Grantham has a large output of petrol-driven farm machinery and road rollers of all kinds.

Of the second class of towns the locomotive-building centres have already been alluded to. A few others may be cited as examples, but it must be remembered that, as pointed out previously, almost every town has an engineering works of some kind. Northampton makes stoves and grates and boot-making machinery; Bedford such things as pumps, oil engines, and electrical gear; Luton makes motor cars, ball-bearings, refrigerating plant; Guildford specialises in mowing machinery; Yeovil makes oil engines; and Oxford has already been mentioned in connection with the motor-car industry.

Despite the absence of coalfields, this south-eastern region, taken as a whole, is the greatest engineering province of all. True, it is unlike the other regions in being far more widespread and in containing far more numerous and scattered individual centres, but within it the great city of London, as the table on p. 427 shows, is the largest employer of engineering labour in the country. The multifarious engineering trades of London are referred to elsewhere (pp. 620, 624–625), but we might note here the importance

[1] This industry began, no doubt, by the keener farmers inventing their own mechanical devices, and became commercialised by the setting up of workshops in the market towns where the farmers congregated. Cf. *Victoria County History*, Lincolnshire, Vol. II, pp. 394–396.

of the electrical and motor trades and of the miscellaneous group. To provide raw material for some of these industries London has over 500 foundries (iron and non-ferrous), ten per cent. of all those in the country.

Finally, attention may be called to South Wales. In this area neither shipbuilding nor any great engineering industry has developed[1] despite the early importance of the iron industry. The reason is to be found (*a*), in the location of the early smelting works in narrow valleys miles from the coast, and (*b*) in the great development of the tin-plate industry (*vide supra*) which absorbs most of

EMPLOYMENT IN ENGINEERING INDUSTRIES IN 1950

(In Thousands)

		Electrical Engineering	Motor Vehicles	Shipbuilding and Marine Engineering	Aircraft	Machine Tools	Tools and Cutlery	Other Metal Industries	Total
1.	Scotland	16	31	77	7	3	1	160	295
2.	Northern Region	24	12	63	—	2	—	82	183
3.	North-Western Region	97	56	39	22	9	2	228	453
4.	East and West Ridings	18	27	7	3	16	32	180	283
5.	Midland Region	99	126	—	10	27	9	374	645
6.	North Midland Region	19	29	3	18	4	1	128	202
7.	Wales	11	11	7	3	—	—	50	82
8.	London and S.E. Region	196	129	24	20	12	7	391	779
9.	London	184	106	14	15	10	7	344	680
	Total Persons employed Great Britain	533	518	278	146	77	52	1,786†	3,390†
	Total Areas 1–8‡	480	421	220	83	73	52	1,593	2,922
	Unemployed	4·4	4 2	11·6	1·4	0·4	0 5	18·2	40 7
	Total employed in G.B. 1931	242	348	151	*	*	43	*	1,483
	Total employed in G.B. 1921	175	275	410	*	*	56	*	1,910

2. Durham, Northumberland and N. Riding of Yorkshire, Cumberland, Westmorland.
3. Cheshire, Lancashire and High Peak District of Derbyshire (viz. Buxton, Glossop, New Mills, Whaley Bridge, Chapel-en-le-Frith).
5. Herefordshire, Shropshire, Staffordshire, Warwickshire, and Worcestershire
6. Derbyshire (except High Peak District), Nottinghamshire, Lincolnshire, Leicestershire, Rutland, and Northamptonshire.
8. London (Admin. County), Middlesex, Kent, Sussex, Surrey, and parts of Essex [(Barking, Chingford, Dagenham, East Ham, Ilford, Leyton, Walthamstow. Wanstead, Woodford, and West Ham) Chigwell and Waltham Holy Cross]; parts of Herts (Barnet, Bushey, Cheshunt, East Barnet, and Barnet rural).

* Comparable figures not available.

† There may be some slight overlap with non-ferrous metals here (cf table on p 457), but even allowing for this the increase over 1921 and 1931 is very striking indeed

‡ Areas omitted from the table are South-west, South, and East.

[1] Newport was quite an important shipbuilding centre in the days of wooden ships, but the industry declined when iron came into favour. It was revived in 1953 with the opening of a new shipyard in which prefabricated sections are assembled in dry dock, and the finished hulls floated out into the River Usk and so to Newport Docks for completion.

the steel output. Only the manufacture of rails and sections, an industry lying on the border line between the *production* of iron and steel and engineering proper, is of any importance. This absence of any great manufacturing industry was largely responsible for the disastrous unemployment in eastern South Wales, which resulted from the decline of the inland centres and the working out of the best coals in that same north-eastern region.[1]

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[1] See *Industrial Survey of South Wales,* Chapter III.

CHAPTER XVIII

THE NON-FERROUS METAL INDUSTRIES [1]

Introductory

THE term non-ferrous applies to all metals other than iron. Of a somewhat lengthy list, however, we are only concerned with a few which are in everyday use for domestic and industrial purposes. These fall roughly into three groups:—

(1) Some of the *baser metals*, such as tin, lead, copper, and zinc, have from very early times been wrought extensively in various parts of Britain, and the home-produced ores, though now almost negligible and supplemented by imports of ores, concentrates, and metal, have given rise to smelting and manufacturing industries of major importance.

(2) Other of the *baser metals*, such as nickel, chromium, and aluminium, have found an increasing number of industrial uses during the present century. They are mostly imported.

(3) Ores of the *precious metals*, gold and silver, have never been worked in any great quantity in Britain,[2] but the demand of a highly civilised and, on the whole, wealthy community for jewellery, plate, and ornaments is responsible for the existence of a large industry concerned with the refining and fabrication of the imported metals.

Like all other mining activities, the winning of non-ferrous ores is a "robber" industry, that is to say, once the ore has been removed from the earth there is no means of inducing the growth of a further supply, and the only available course is to close and abandon the mine. Although this is true of all mining, however—and we have already seen in Chapter XVI the examples of the coal and claybands of the Black Country and of the Cleveland ironstone—it is especially evident in the case of the non-ferrous ores. Coal, like most of the British iron ores, occurs in fairly thick seams, interbedded with unproductive measures; and the investigation of the underground extension and probable reserves is a matter of comparative simplicity. The characteristic mode of occurrence of the non-ferrous ores, on the other hand, is in the form of veins, often more or less vertically disposed, and irregular masses, the outcrop of which gives little or no

[1] By S. H. Beaver.

[2] Considerable quantities of silver have from time to time, in the past, been obtained from argentiferous ores of lead, in the Mendips, Derbyshire, and elsewhere. See also pp. 333, 432.

indication of the amount of ore existing underground. Consequently, an ore which may on the surface appear extremely valuable may quickly peter out or alter its character, when traced downwards, and become almost worthless, whilst untold wealth may exist beneath poor surface indications. The working of non-ferrous ores is thus a much more speculative and ephemeral business than coal or iron-stone mining, and is subject to more violent fluctuations of output and profits. It is an occupation, moreover, subject to a greater extent than these industries, to what economists call the "law of diminishing returns"—the more ore is removed from the mine, the more difficult and costly is it to obtain a further supply, for the mine must go deeper, more water must be pumped out, and there will be greater expense for ventilation and haulage. The conditions under which veins and masses of ore may occur are many and varied, so that no two mines, generally speaking, will have identical production costs. It follows then that some concerns in a mining area may be making large profits whilst others are, at least temporarily, running at a loss. The discovery of a new vein, or the opening up of a new ore-field, may quickly stifle, owing to the disparity in working expenses, an old area which may once have been of major importance. Thus the working of a non-ferrous mining field is not controlled solely by the local geological and geographical conditions. Much metal wealth, especially of tin and lead, still remains locked up in British rocks, but the once important veins of Cornwall, Derbyshire, and elsewhere cannot under present economic conditions hope to compete with the large-scale output from much richer areas abroad; the result being that the mining of non-ferrous ores in Britain is now virtually an extinct industry, and the manufactures to which the home deposits originally gave rise must now be carried on almost entirely with imported foreign ores, concentrates, or crude metal.

There are many areas of the country where non-ferrous ores have been worked, and many thousands of extinct mines (some 4,000 disused lead mines in Derbyshire alone). But the life of a metalliferous mine is generally, with some very notable exceptions, comparatively short. Hunt calculated [1] for a 30-year period in the second half of the last century that of 220 Cornish mines only 35 had a life of over 20 years, whilst no less than 114 were productive for less than five years. As every mine must have a dump heap of the useless rock dug out during the mining operations, and an erection of some kind at the head of the shaft, it is obvious that the effect on the landscape of those areas which have been thoroughly worked in the past must be considerable; and many a Cornish and Welsh panorama is marred by the ugly excrescences which betoken an activity which is, alas, rapidly fading into insignificance.

[1] Quoted in *Mem. Geol. Surv., Min. Res.*, Vol. XXVII.

The industries based upon the non-ferrous metals and their extraction fall naturally into two distinct divisions: (*a*) the smelting and refining of the ores, and (*b*) the working up of the metal into manufactured articles. The geographic and economic influences bearing upon the location of the two branches are rather different. In the case of the smelting it must be borne in mind that most non-ferrous ores are very much poorer in their metallic content than ores of iron. A percentage as low as one per cent. may prove profitable if the ore is in sufficient quantity and easily accessible. The ore from the world-famous Anglesey mines, once the most productive in the world, only averaged four per cent. of metallic copper. It is thus not an economic proposition to smelt the ores far from their place of origin, unless cheap water transport be available, or unless the ore can be conveniently concentrated so that its metallic content is increased, say, to over 50 per cent. With inland ores smelting will most probably take place at the mines; should the ore lie near the coast it may be exported raw or in concentrated form to ports more favourably situated with regard to coal. The Derbyshire lead was always smelted on the spot; the Cornish copper ores were sent across the Bristol Channel to the ports of south-west Wales.

The location of the manufacturing industries is dependent upon at least three factors, the existence of a supply of raw material in the form of refined metal, a suitable labour supply, and the presence of a market for the finished goods. Should the market be a scattered one, it can scarcely be expected to influence the siting of the works, for one locality would be as good as another. Under these circumstances the factories may be set up, either in the vicinity of the smelting and refining plants, or distributed in a haphazard fashion over the country. If, on the other hand, the market is localised in a particular region or regions, the tendency will be for the manufacture to take place as near as possible to those areas. A second consideration concerns the wastage of the raw materials during the process of manufacture. If there is little or no waste the amount of material to be transported is much the same whether the raw materials or the finished goods are sent, and so it matters little where the industry is located on a line drawn from the source of the raw materials to the market. If, however, there is a great wastage of material the market will exert much less attractive power, and the manufacture will tend to be located near the source of supply of the raw material.

With these general principles in mind, we may proceed to examine in some detail the past and present distribution of the non-ferrous metal industries in Britain, paying special attention to the changes in location which have occurred, and to the geographical influences (in this case mainly a combination of geological and economic factors) which have been foremost in producing them.

THE DEVELOPMENT OF THE NON-FERROUS METAL INDUSTRIES

From the earliest times to the reign of Elizabeth [1]

The early history of the working of non-ferrous metals, like that of iron, is lost in obscurity. It is probable, however, that the western end of the Cornish peninsula, with its indented rocky coast, and the adjacent Scilly Isles were the Cassiterides to which the Phœnicians came from at least the fifth century B.C. to trade in tin with the natives.[2] By the time of the Roman occupation there is abundant evidence, both literary and *in situ*, of the great use which the Romans (with the help doubtless of their slaves) made of Britain's metal wealth. The historian, Diodorus Siculus, writing of the Cornish tin trade just after Cæsar's time, records the collection of the smelted tin on Ictis Isle (probably St. Michael's Mount) and its purchase by the merchants for shipment to the coast of Gaul and thence to Marseilles and the Mediterranean, and a block of tin such as he describes has actually been dredged up from Falmouth harbour. But it was lead that the Romans chiefly prized, and the results of their mining and smelting operations are to be found in such widely scattered localities as the Mendips, Derbyshire, Flintshire, western Shropshire, Alston Moor, and Leadhills. A very fair technique had been attained, for numerous pigs of lead have been unearthed bearing the inscription "ex arg" (*ex argento*, freed from silver), and Pliny refers to the large supplies of lead pipes and sheeting which Britain produced. In addition, the Romans are known to have worked the copper ores of Anglesey and Shropshire, whilst it is not improbable that they obtained a certain amount of gold from mines in North Wales and Carmarthenshire.

All these early efforts were either stream-works or else mere surface scratchings. The natural environment in which the ores occurred was particularly favourable to their discovery and utilisation. The veins were to be found in upland areas formed by palæozoic rocks, and the thin soils and scanty vegetation of much of these districts permitted the surface exposure of the minerals; the heavy rainfall of most of the upland regions entailed a great deal of erosion by rushing torrents which would further expose and erode the veins and would sort and re-deposit the ore in their beds; whilst

[1] Much valuable literature on this subject will be found summarised in the *Victoria County Histories* (Vol. II in each case) of Cumberland, Derbyshire, Durham, Somerset, and Yorkshire.

[2] Cassiterides, from Greek *cassiteros*=tin. See W. C. Borlase, *A Historical Sketch of the Tin Trade in Cornwall*, 1874. Herodotus (fifth century B.C.) and Strabo (first century B.C.) each refer to the Cassiterides and their tin, and Polybius (second century B.C.) and Diodorus Siculus (first century A.D.) both mention tin in Cornwall, but no definite pronouncement seems to be made identifying the one with the other. A Phœnician bronze ornament has been found at St. Just.

the peat cover of much of the moorland and the forests of the slopes would provide ample fuel for smelting purposes. The Cornish tin ore was probably all obtained from detrital deposits in which, owing to its high specific gravity (6·8), it accumulated whenever the velocity of the streams was insufficient to carry it further; and the ores of the other regions were obtained either from streams or by shallow diggings at the outcrop of the veins.

There are few records of mining or smelting during the Saxon period, and the only noteworthy reference in the Domesday Survey concerns lead mines at Wirksworth and other places in Derbyshire.[1] The first documentary evidence begins in the twelfth century, and the long series of Pipe Rolls contain frequent references to the mining industry, in which tin and lead are the chief items.

Tin.[2]—In the twelfth and thirteenth centuries, the Cornish tin trade was mostly in the hands of Jews who may or may not have been the descendants of Phœnicians who settled in the country. Even to this day certain ruined smelting hearths and slag dumps are known as "Jews-houses." The banishment of all Jews from England in 1290 left Cornwall without its merchant smelters, but a revival of industry took place in the early fourteenth century with the passing of the first Stannary Laws (Latin *stannum*=tin). So great a part did tin mining and tin smelting play in the lives of the people of Devon and Cornwall that from this time onwards for over four centuries the "Stannaries" had their own Parliaments,[3] and a series of laws governing the mining, coinage, and disposal of tin. "Coinage" was the marking of the tin bars for taxation purposes. It took place generally once a year at certain "coinage towns," whither the bars were brought from the neighbouring smelting houses. In Cornwall, Lostwithiel, Liskeard, Bodmin, Truro, and Helston were appointed as coinage towns, and in Devon, Tavistock, Ashburton, Plympton, and Chagford. The chief uses of tin were for the manufacture of pewter, as an alloy in bell-founding and as a soldering material. The pewter trade assumed large proportions in the fifteenth and sixteenth centuries, and a considerable export took place, largely controlled by Venetian merchants.

Lead.[4]—The twelfth and thirteenth centuries saw great activity all over the country in the erection of great buildings—especially churches and monasteries—and as a result the demand for lead for roofing and drainage purposes was greatly stimulated. Derbyshire

[1] It is difficult to believe that tin-mining had died out—but possibly, being considered as royal property, the mines were not recorded in a survey, the main purpose of which was the ascertainment of the value of estates for taxation purposes. (G. R. Lewis, *The Stannaries*, p. 34.)

[2] G. R. Lewis, *op. cit.*, Chapter II.

[3] The parliament of the Devon "stannary" met on Crockerntor and later at Tavistock; that of Cornwall met at Lostwithiel and afterwards at Truro.

[4] See especially *Victoria County History*, Derbyshire, II, 323–349; also J. W. Gough, *The Mines of Mendip*, Oxford, 1930.

was the chief centre, but the Pennine region of Durham and the Mendip Hills also had many mines and smelting hearths. Smelting of the galena was performed in "boles" (simple hearths surrounded by a few bricks) using brushwood as a fuel. These boles were nearly always placed on the brow of a west-facing hill, in order to catch the breeze. Many such ancient furnace sites are known in Derbyshire and Durham, and the name "Bole Hill" is of frequent occurrence in the former county. The fourteenth century probably witnessed the introduction of charcoal as a fuel, and also the development of water-wheels for working bellows which could create the necessary blast—with a consequent descent of the smelting industry into the valleys. At this time lead ranked with wool and leather as one of the chief exports of Britain.

From the reign of Elizabeth to the present day

The history of the non-ferrous metal industries from about 1550 to the present day may be briefly summed up as follows. A great fillip was given to mining and smelting in the Elizabethan period by the introduction of workmen from the Continent who could and did teach the English how best to search for and make use of the metal wealth which the country possessed. The small existing industries were considerably expanded, and a number of new manufactures, such as those dealing with copper and brass, came into being. After a period of comparative quiescence during the troublous times of the middle seventeenth century, a great revival took place. The end of that century and the beginning of the next marked the foundation, in various parts of the country, of many branches of the industry which have survived, though perhaps in a modified form, until the present day. The increasing uses to which the metals were being adapted, together with the new lease of life given to the mining industry by the installation of the steam engine as a means of pumping out water from the ever-deepening mines, brought about a continued expansion of the industry during the eighteenth century. Stimulated by the development of manufacturing which accompanied the Industrial Revolution, and by the increasing employment of non-ferrous metals as well as iron in the fabrication of machinery, the output of British mines reached a maximum during the period 1840–1880. About the same time, too, foreign ores, especially of tin and copper, began to be imported, and the smelting trade, notably in the Swansea area, enjoyed a period of great activity. Gradually, however, it became increasingly uneconomic to transport bulky ores for thousands of miles from overseas, and as this trend has coincided with the decline, almost to nothing, of the home ore production, smelting has almost died out, and the structure of the non-ferrous metal industry has been radically changed. Most branches of the industry are carrying on as a

result of momentum acquired during the period of prosperity, and are now based upon imported semi-finished material in the shape of ingots and bars of refined or partly refined metal.

A more detailed examination of the development and distribution changes during this period will help to explain how the British non-ferrous metal industry and its dependants have been built up, and the part which they play in the economic organisation of the country at the present time.

In the middle of the sixteenth century, although tin and lead were still being worked, England lagged a good deal behind the Continent in industrial development, and early in the reign of Elizabeth it began to be realised that in order to improve conditions at home, to increase foreign trade, and to maintain the defences, metal industries were very necessary, especially those dealing with copper and brass, since those substances were used for the production of ordnance as well as for domestic utensils.[1] Accordingly, invitations were extended to certain German metal workers to take up their abode in this country and pursue their trade with British ores. In 1564 a small group of skilled men from Augsberg, led by one Daniel Höchstetter, landed in England, and in the following year, after rich copper deposits had been located at Keswick, several hundred workmen from the Tyrol were "imported" and smelting works were set up. Many groups of German miners and metal workers subsequently came to Britain and settled in the mining districts, notably in Cornwall, the Mendips, and in Northumberland, or started new metal industries in various parts of the country.[2] Two companies were subsequently formed and granted charters, one the "Mines Royal Society," whose privilege it was to work for precious metals and copper in certain areas, and the other the "Society of the Mineral and Battery Works," who were authorised to get calamine (zinc ore), and to make brass and battery goods (i.e. articles, such as pans and kettles, made from copper or brass beaten into thin sheets). In 1583 copper ore began to be worked in western Cornwall, and as there was no fuel there available, a smelting house was set up at Neath, in South Wales, to deal with the ore. A little later copper ore was discovered at Ecton Hill, Staffordshire, and Alderley Edge, Cheshire, and smelting works were set up in the vicinity. The chief essentials of the smelting industry were ore supplies and the availability of fuel. At Keswick peat was used; at Neath charcoal and coal. The brass industry, on the other hand, needed calamine and copper as its raw materials, and power for the hammers, and was best placed near to a market. The first brass works were at Tintern (using the calamine

[1] See on this subject H. Hamilton, *The English Brass and Copper Industries to 1800*.

[2] Many of the early metal-working establishments owe their foundation not to any geographical advantages possessed by the site but to the settling of a group of foreign artisans.

lately discovered in the Mendips, together with fuel from the Forest of Dean), at Nottingham (using Derbyshire calamine and Staffordshire copper), and on small streams near London (at Isleworth and Rotherhithe). One of the principal uses of brass, apart from "battery goods," was for wire and pin-making—the chief activity of the Mineral and Battery Society was the production of iron and brass wire for wool-cards.

The political instability of the Civil War and Protectorate period, and the monopolistic control exercised by the two companies mentioned, were unfavourable to great progress; [1] but with the removal of the monopolies in 1689, the way was opened for a considerable expansion in the copper and brass trades, and the improvements in mining and smelting technique which naturally followed, further increased the possibilities of development. During the eighteenth century several areas participated in the general growth of the non-ferrous metal industries. Around Swansea and Neath, the chief activity was smelting, using copper ores imported by sea from Cornwall and Ireland (Co. Wicklow), and silver-lead ore from Cardiganshire. Swansea was at this time the chief port in South Wales—and the nearest to Cornwall—and as it possessed a navigable river, easy access to coal supplies and a large area of flat and otherwise useless land behind it, it offered a very favourable site for the growth of the copper trade. All these advantages were largely shared by Neath. In the Bristol district the ease of the import of Cornish copper ore,[2] the proximity of the Mendip calamine deposits, and the water power provided by the Avon and its tributaries, resulted in both smelting and brass manufacturing. The third region comprises north Staffordshire, north-east Cheshire, and south Lancashire. Here the initial impetus was given by the local copper ores and the calamine of Derbyshire, and the ease of import of copper ore from Ireland. Quite early in the eighteenth century, smelting works were established at Warrington,[3] and copper and brass battery and wire works in the Cheadle district, where water power from the River Churnet was utilised. The greatest development here, however, came after the discovery, in 1768, of a whole hill of copper ore in the island of Anglesey.[4] Although some smelting was done at Amlwch, near the mines, much of the ore was exported; St. Helens and Liverpool developed smelting works, and the Macclesfield area took up the brass industry. Considerable quantities of

[1] In 1670 and again later the copper required for a new coinage had to be imported from Sweden.

[2] In 1720 no less than forty ships were constantly employed to carry Cornish ore to Bristol and Swansea.

[3] Warrington at that time had just, by the dredging of the Mersey, been made available as a tidal port.

[4] The Parys mine quickly became the largest in Europe, and at the end of the century was yielding about 3,000 tons of metallic copper annually.

Anglesey ore were also exported to Swansea, where many new works were established. Smelting was tried in Cornwall on several occasions, but none of the attempts really succeeded, principally because of the coal difficulty, but also because the greater part of the British copper-smelting industry was under the control of large combines which could effectively crush any competition from less well organised competitors.[1]

The chief outlets for the copper and brass made were the East India Company, which largely controlled the export trade, and the metal trades of Birmingham.[2] These deserve further comment. In the sixteenth century Birmingham was already a centre of the finished iron industry (*vide supra*, page 424). When brass manufacture first began to develop, early in the seventeenth century, Birmingham was thus a natural market; brass is more easy to fabricate than iron, and the skill of the ironworkers could be readily adapted to the use of the new metal. The local demand for brass products was stimulated by the gun, saddlery and harness trades, and the output of buckles, ornaments, and toys increased rapidly after the Restoration. Bad road transport and the lack of navigable rivers made Birmingham specialise in small and valuable goods, whilst the heavy iron trades became localised farther west, where coal and water-power (e.g. in the Stour valley) were available, with the navigable Severn not far away. The development of the smelting and brass-making industries at Bristol and Cheadle, together with the expansion of the export trade to Africa and the Indies, gave Birmingham an impetus in the manufacture of metal wares that has sufficed to maintain its supremacy in the trades, even to the present time; and the desire to break the power of the combines (*vide supra*) led to the setting up of brass manufacturing (as opposed to the fabrication of brass articles) towards the end of the eighteenth century. Besides Birmingham, Wolverhampton and Walsall also began to develop brass and copper industries; in Wolverhampton the industry grew up primarily as an associate of the lock trade; in Walsall of the saddlery and harness trades.

The eighteenth century witnessed the lead industry at the height of its prosperity. Lead had not been affected to such an extent as the copper and brass trades by the disturbing effects of control by large companies, export and import restrictions, and fashion changes, but, favoured by a flourishing export trade, had undergone a steady development. In Derbyshire the lead miners, most of whom were individualists working for their own ends, and selling the ore from their own small digging or mine to merchant smelters, were governed by laws even more numerous and complicated than the Stannary Laws of Devon and Cornwall; and as most of the mines were small and the laws permitted anyone to dig for lead anywhere, and to

[1] Hamilton, *op. cit.*, Chapter VI

[2] Hamilton, *op. cit.*, Chapter V.

remove timber for propping and smelting, the effect on the landscape of the lead-mining area lying between Wirksworth and the Peak Forest has been considerable. Other lead-mining and smelting regions at this time were Flintshire, the Leadhills region, the Mendips (though the lead here began to be subordinate to zinc—*vide infra*), and the Pennines of north Yorkshire and western Durham.[1] Lead was used for sheeting, pipes, and bullets.

The tin-mining industry of Cornwall was given a considerable impetus after about 1730 by the growth of the tin-plate trade in South Wales (cf. Chapter XVII). Despite the commencement of the import of tin ore from the East Indian island of Banka in 1760, this trade, combined with the export market provided by the East India Company, sufficed to maintain the Cornish mines in a state of comparative prosperity. A considerable amount of tin-smelting was performed in Cornwall—probably owing to the very early start which the industry had, using peat and charcoal as fuel, and to the fact that unlike the copper trades, tin mining was confined to the one area, and so not subject to competition from better situated producers.

The need of the brass industry for calamine has already been mentioned. In the early days of brass manufacture prepared calamine was used to mix with copper. About the middle of the eighteenth century, however, methods of extracting metallic zinc, or spelter, from both calamine ($ZnCO_3$) and blende (ZnS) were discovered, and later spelter was used in brass making. The first zinc-smelting works was set up at Bristol in 1743, and thereafter the mining of zinc ores became of still greater importance in the Mendips, where nearly 100 mines were in existence at the end of the eighteenth century.

The outstanding technical developments which influenced metal production in the nineteenth century were concerned with (*a*) more efficient mining methods—i.e. better drainage and ventilation; (*b*) better treatment (washing and crushing) of the ore, so as to get the utmost possible metal out of it; both of these were greatly assisted by the employment of the steam engine; (*c*) improved methods of smelting—the introduction of cupolas and reverberatory furnaces using coal or coke as a fuel; (*d*) the introduction of rolling as opposed to battery in the production of sheet metal. The development of coke smelting and the use of steam power did not, however, as with the iron industry, tend to concentrate the non-ferrous metal industry on the coalfields; for the lean ores were not found in the Coal Measures, and the smelting industry was located either on the ore-fields, as in the case of Derbyshire lead and Cornish

[1] A. E. Smailes, "The Lead Dales of the Northern Pennines," *Geography*, XXI, 1936, pp. 120–129; "Geology of the Northern Pennine Orefield," Vol. 1 (*Mem. Geol. Surv.*), 1948.

tin, or near the coast, where either home or foreign ores could be easily imported, as in the Swansea and Bristol areas and in South Lancashire.

The progress of the non-ferrous metal industries during the nineteenth and early twentieth centuries can be best treated under three headings: (1) Ore mining; (2) Ore import and smelting; (3) Manufacturing trades.

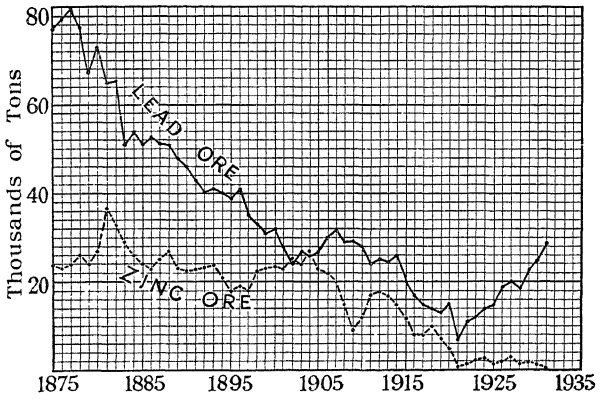

FIG. 211—Lead- and zinc-ore production in Britain, 1875–1935

Since the Second World War, zinc ore has almost ceased to be produced, whilst the output of lead ore has averaged only 3,000 tons a year

(1) *Mining.*—Taken as a whole, production of non-ferrous ores reached its maximum during the middle period of the last century, though different ores and different regions reached their climax at varying dates. In the early years of the century, Cornwall and Devon were producing about half of the world's copper ore, but although the actual amount increased until about 1860, the tremendous outputs of Chile and the United States soon dwarfed this into insignificance. The Anglesey ores were gradually worked out, and although between 1850 and 1870 North Wales and the Lake District were fairly productive, a rapid decline quickly set in. In lead mining, the peak period was 1850–1870 when the average output was over 90,000 tons of ore annually. Derbyshire no longer dominated the industry, the northern Pennines and North Wales producing large quantities. The Cornish tin mines continued to increase their productivity, reaching a maximum between 1870 and 1890, subsequently declining. Zinc mining attained its greatest output in 1881 and declined gradually.

The general rapid decline of ore production in the last quarter of the century may be ascribed to several causes. Mining conditions were becoming more and more unfavourable, and the best ores were

worked out; prices during the great depression of the 'seventies dropped to ruinously low levels, rendering the working of many mines quite unremunerative; [1] the rapid growth of steam shipping, and the development of large bodies of ore in foreign countries, made for easy import of ores and concentrates—copper from Chile and the United States, lead from Spain (where it was a by-product of the silver mines), tin from Australia and Malaya.

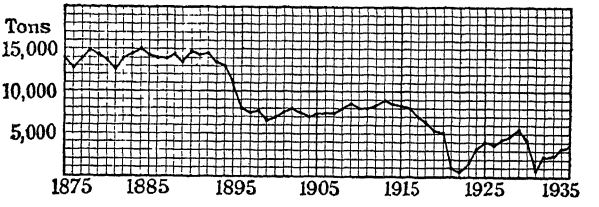

FIG. 212—Tin-ore production in Britain, 1875–1935

Since the Second World War, production has averaged less than 1,000 tons a year

(2) *Smelting*.—The nineteenth-century smelting industry affords some excellent examples of the results of changing geographical values. The rise of Swansea has already been mentioned. The expansion of the Cornish output of copper ore continued to stimulate the erection of new works on the River Tawe; four (also one at Llanelly) were actually built during the first decade of the century. After about 1830, foreign ores from Cuba and Chile began to supplement the Cornish supplies, and the growth of smelting at Swansea was, as it were, cumulative: the very existence of a number of smelting works, and of a labour supply skilled in metal working was sufficient to attract any new enterprises to the vicinity, and Swansea assumed the position of the world's chief copper-smelting centre.[2] In the 'sixties, when the trade was at its greatest, Swansea boasted eight copper-smelting establishments out of a total of sixteen in South Wales, and twenty-four in the whole country. The effect of this vast industry upon the landscape has been disastrous. The sulphurous fumes belched forth from hundreds of chimneys during the roasting and smelting operations destroyed the vegetation for miles around, especially on the east side of the Tawe (due to the prevailing westerly winds) and the enormous slag dumps, together with numerous ruined factories, combine to make the entry by rail into Swansea a most depressing journey. The increase of ore-field smelting, however, reduced the industry at Swansea to a state when economic competition with Chile, the United States, and Australia

[1] It should be remembered also that unless pumping is carried on a disused mine quickly gets flooded and the outlay involved in putting it again into working order may be prohibitive.

[2] See G. Grant-Francis, *History of Copper Smelting in the Swansea District*, and D. T. Williams, *Economic Development of Swansea*.

was no longer possible and, as a result, from the late 'eighties onwards, copper smelting declined until it no longer exists. Instead, smelted copper ("matte" or "regulus") is imported and refined. The other smelting activities of Swansea (lead and zinc) were formerly of much less importance, but strangely enough they have survived the copper smelting (*vide infra*).

The only other copper-smelting centre of importance in the nineteenth century (apart from the declining ore-field smelters at Amlwch and Cheadle) was St. Helens, with the origin of which we have already dealt (Fig. 213).

FIG. 213.—Copper-smelting works in 1861

The smelting of lead was much more widely distributed, owing chiefly to the fact that rich ores were abundant in many parts of the country, but also to the ease of smelting and the absence of destructive fumes (Fig. 214). In Derbyshire (centring upon Matlock), in Cornwall, Flintshire, Shropshire, the north Pennines, the Mendips, and at Leadhills, the smelting works were located in close proximity to the larger mines. Bristol, also an important centre for other non-ferrous metals, used ore from the Mendips or imported from North Wales. A few works in the Llanelly region used north Welsh ore, and Newcastle-on-Tyne smelted ores from Alston Moor, or imported by sea. The rapid decline of mining, however, has considerably reduced the number of works in operation, and the greater part of the British lead production is now derived from imported

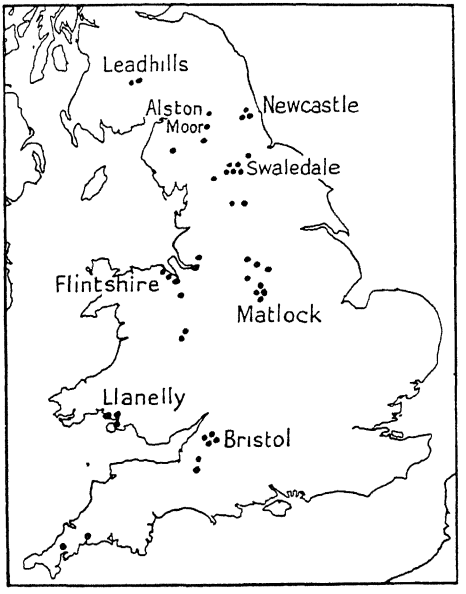

FIG. 214.—Lead-smelting works in 1870

pig-lead, which is refined principally at or near the chief sea-ports.

Although certain of the Cornish tin smelters for a time actually imported East Indian and Australian ore for smelting, the trade has suffered the same fate as the rest of the industry; concentrates are now imported to be smelted at Liverpool or London, and refined tin bars are imported for the tin-plate trade.

(3) *Manufacturing.*—If, during the nineteenth century, Swansea merited the title of "metallurgical capital" of Britain (in non-ferrous metals only, of course), Birmingham to an even greater extent deserved to be regarded as the metropolis of those industries concerned with the working of the non-ferrous metals into articles of commerce.[1] The momentum which that city had acquired in the brass and copper trades during the eighteenth century, was sufficient to attract any new developments, and so greatly did the market for copper and brass expand during the first half of the nineteenth century that by 1860 brass manufacture was the leading trade in Birmingham. The development of the steam-engine had added a vast new market for brass and copper tubes, steam cocks, pressure gauges, etc., and the invention of a method of making seamless tubes in 1838 gave a further impetus to this branch; the introduction of yellow or Muntz's metal for ship-sheathing early in the century, and the demand for "naval brassfoundry" to which the expansion of shipping gave rise, created a new market; and the increase in domestic and municipal sanitation generated a large demand for taps, water-cocks, etc., whilst gas lighting opened up a new market for pipes and fittings. In 1830, the crucible method of brass manufacture (using copper and spelter) began to replace the old cementation process, and this, like Bessemer's converter in the steel industry, caused a considerable expansion of output, and a reduction of operating costs. Birmingham was, moreover, particularly well situated, following the cutting of canals, for the assembly of raw materials and coal, and was conveniently near to certain accessories of brass manufacture—fireclay crucibles from the Stourbridge district, and local Triassic deposits which furnished excellent moulding or casting sand. It is little wonder, then, that the number of people employed in the brass industry in the city rose from 1,800 in 1831 to 8,100 in 1861.

It was natural, too, that a city devoted so largely to the working of the baser metals should turn its attention to silver, gold, and the jewellery trade. Birmingham began with silver, but early in the nineteenth century gold was being worked as well, and the increasing demand for jewellery in the early years of Queen Victoria's reign, together with the expansion of the gold trade following the "rushes" in California and Australia in 1849–1851, brought about a rapid growth,

[1] See G. C. Allen, *Industrial Development of Birmingham and the Black Country.*

and by 1860 the jewellery trade was one of the four largest in Birmingham, employing about 7,000 people, mostly small craftsmen working in their own workshop-dwellings. The introduction of electro-plating about 1840 opened up a vast new market. The silver-plate trade introduced into Sheffield about 1740 had been shared by Birmingham, and the two cities both profited very largely by the great demand which was set up by the cheapening of plated articles without any loss of utility and attractiveness.

To an even greater extent than the brass and copper industries, the jewellery trade depended on foreign raw materials. As a consequence, when competition from better-situated continental and American producers became keen, concentration upon high-class goods became a feature of the trade.

Both the brass and the jewellery trades survived in Birmingham and even expanded considerably, whilst the iron industry was rapidly declining. The cheapening of copper by reason of the huge foreign supplies available, and the vast increase in the use of steam-driven machinery, together with the fact that Birmingham had always been dependent on distant sources of raw materials, and so did not suffer, as in its iron industry, from the disadvantage of failing local supplies, combined to maintain and increase the prosperity of the brass trade. The jewellery industry, augmented by the introduction of jewel-cutting and by the continual increase of electro-plating, flourished likewise.

At the beginning of the present century we thus see the various branches of the non-ferrous metal industry very different in magnitude, and in relative importance, though not radically different in geographical distribution, compared with their condition in 1800. Smelting had declined almost to nothing; instead or ores, ingots of semi-refined or pure metal were being imported; and the manufacturing industry, helped by the creation of many new uses for the metals, had grown almost out of all recognition, especially in the Birmingham district.

Before dealing with the present condition of the industry, we must glance briefly at the sources of the raw materials; we can then study the distribution of the various branches of the industry and amplify the explanations hitherto given of the geographical factors involved.

THE PRESENT CONDITION OF THE NON-FERROUS METAL INDUSTRIES

Home Supplies of Ore

Some details of the British metalliferous ores have already been given in Chapter XV. It only remains for us to add the table on p. 444, which demonstrates the demise of a once great industry.

OUTPUT OF NON-FERROUS METALLIFEROUS ORES (TONS)

Mineral	Chief localities	Average per cent. of metal in dressed ore	1913	Average 1921–25	Average 1926–30	1931	1934	1937	1944	1949	1950
Copper precipitate [1]	Cornwall Anglesey	63	163	149	123	109	23	79	27	—	—
Lead ore . . .	Derby Durham Cumberland Dumfries	80	24,282	12,048	21,583	29,502	68,122	33,411	3,969	2,465	3,285
Manganese ore. .	Merioneth Caernarvon	30	5,393	1,214	624 [2]	—	—	—	17,607 [3]	—	—
Tin ore . . .	Cornwall	60	8,355	2,195	4,566	919	3,224	3,367	1,289	820	881
Zinc ore . . .	Cumberland Derby Flint Dumfries	46	17,294	1,696	1,913	409	988	13,083	8,663	—	36
No. of persons employed in all non-ferrous mining (including barytes)	—	—	—	3,406	4,603	1,380	3,270	3,711	*	*	*

[1] Copper *ore*, 2,569 tons, 1913; practically none since 1920.
[2] 1926–1928 only.
[3] Wartime output only.
* No comparable figures available.

Imports of Ores and Metals

It is obvious that the small quantities of metal to be obtained from the ores enumerated above could not form the basis of any large manufacturing industry. In order to maintain the vast industries which grew up during the nineteenth century, therefore, recourse must be had to the import of raw materials from abroad. The greater part of the raw material is in the form of crude metal (already smelted and perhaps refined); some ores and concentrates, however (notably zinc from Australia, and bauxite, the ore of aluminium), are still imported by certain ports where the smelting industry, favoured by a coastal situation, is not entirely extinct (e.g. Swansea, Liverpool, Bristol).

NON-FERROUS METAL INDUSTRY: IMPORTS OF RAW MATERIAL, 1951

I. *Ores and Concentrates*

Material	Thousand tons	Chief countries of origin	Chief receiving ports [1]
Antimony ores and concentrates	26	—	—
Bauxite	345	Gold Coast, France, British Guiana	Burntisland, Newport
Chromium ore	132	Southern Rhodesia	Manchester
Manganese ore [2]	381	India, S. Africa, Gold Coast	Middlesbrough, Liverpool, Manchester
Pyrites [3]	348	—	Liverpool [4]
Tin ore and concentrates	51	Bolivia, Nigeria	Liverpool
Tungsten ores	5	Portugal, Burma, Bolivia	—
Zinc concentrates	180	Australia	Swansea, Bristol

II. *Crude Metal*

Aluminium	176	Canada, Norway	Liverpool, London, Manchester, Newport
Copper	355	N. Rhodesia, U.S.A., Belgium	Liverpool, London, Manchester, Swansea
Lead	175	Australia, Canada, France	London, Liverpool, Manchester, Newcastle
Tin	10	British Malaya	London
Zinc (Spelter)	122	Canada, Belgium, U.S.A., Australia	London, Liverpool, Swansea

[1] Where no port is given, no port imports in quantities sufficiently large to be recorded separately in Trade Statistics.

[2] Manganese ore is not imported for the production of metallic manganese, but is used in the steel industry; see Chapter XVI, p. 371. No further mention will be made of it in this chapter.

[3] Pyrites includes both iron pyrites (FeS_2) and copper pyrites ($CuFeS_2$). Iron pyrites is imported for the sulphur and not for the iron.

[4] Many ports receive iron pyrites since its chief use is in gas-works. Liverpool is the chief recipient of Spanish copper pyrites, used in the Lancashire chemical industry (cf. Chapter XXII).

CHIEF PORTS IMPORTING NON-FERROUS ORES, CONCENTRATES, AND CRUDE METAL, 1948 [1]

(Thousand Tons)

Port	Bauxite	Crude aluminium	Copper bars	Pig-lead	Zinc ore	Crude zinc	Tin ores and conc.	Total
Bristol	—	17	16	4	99	19	—	156
Liverpool	—	21	143	53	—	39	46	307
Manchester	—	28	30	15	—	17	—	143 [2]
London	—	20	128	69	—	75	—	293
Newport	102	22	—	—	—	—	—	126
Swansea	—	16	6	—	—	58	—	93
Burntisland	135	—	—	—	—	—	—	135
Glasgow	—	15	—	10	—	6	—	32

[1] Excluding manganese ore; see note 2 to table on p. 445.
[2] Includes 53,000 tons of chromium ore.

Besides continuing their smelting industry, though in a greatly reduced and modified form, these old coastal centres have also turned over to the working up of imported metal into sheets, bars, wire, and tubes, and as a result they figure largely also in the second part of the table, above. But the weight of a given quantity of crude metal will be very little reduced after manufacturing, and in consequence, unlike the ores, this raw material will stand the cost of transport to inland centres. Needing no special accommodation, it can be dealt with to a very large extent by the great ports, London, Liverpool, Manchester, in the course of their ordinary import trade. The large part which these ports play in the import of crude metal is, however, partly accounted for by the existence at all three of important refining and manufacturing industries; but London, especially, imports far greater quantities than its own works can consume, the surplus going to the Midlands or as far afield as South Wales.

The Non-Ferrous Metal Industries considered separately

Aluminium.[1]—This, one of the most abundant metals in the earth's crust, has given rise to the youngest of the great non-ferrous metal industries. Its development dates really from about 1900, and the reason is to be found in the difficulty of reduction, and the comparative scarcity of readily usable ores. Although alumina is present in all clays, bauxite (a mixture of diaspore $Al_2O_3.H_2O$, and gibbsite $Al_2O_3.3H_2O$), the name derived from Baux in southern France, is as yet the chief commercial source of the metal. The production of aluminium is effected in two stages: (1) by a com-

[1] See W. G. Rumbold, *Bauxite and Aluminium* (Imperial Institute Monographs on Mineral Resources).

plicated chemical process, nearly pure alumina is obtained from the bauxite: (2) the alumina is calcined and then reduced in an electric furnace employing a current of great intensity. It is the necessity for electric power on a large scale which has been the chief obstacle to the spread of aluminium manufacture, and which has caused the concentration of the industry mainly near hydro-electric power sites. In Britain, the production of the metal is divided into two quite distinct parts. The extraction of alumina from imported bauxite is effected at Burntisland; the works at Larne, which were based on the Antrim bauxites, have been closed, but in 1939 large new works were established at Newport in South Wales. The reduction of the alumina is effected at hydro-electric power works which have been erected in the Scottish Highlands (at Fort William and Foyers (Inverness) and Kinlochleven (Argyll). The annual output of aluminium ingots is about 30,000 tons. Although both Burntisland and Newport, being seaports, are fairly conveniently situated with regard to the import of bauxite it is obvious that a great deal of transport is necessary before the metal aluminium is finally produced; and as the power stations are far removed from the great metal-working centres a further journey is necessary before the metal finally enters the market as a finished article. For this reason it is a great advantage that aluminium is a metal of extreme lightness (Sp. Gr. 2·7).

Another works at Newport, established during the Second World War, recovers aluminium from aluminium dross.

In half a century many uses have been found for aluminium, based mainly upon its lightness combined with strength, malleability and ductility, and the ease with which it can be mixed with other metals. Unalloyed, it is used for electric cable wire (especially the bare overhead lines of the Grid), in motor-car and aircraft construction, and for hollow-ware (i.e. cooking utensils). Alloyed with copper, zinc, or with two or more other metals, for the purpose of combining lightness with tensile strength, it is used for pistons, cylinders, and other parts of aircraft and motor-car engines (as opposed to framework). The metallurgy of aluminium and its alloys is still in its infancy. Two world wars gave a tremendous stimulus to the production of aluminium for aircraft, and the rapid post-1918 expansion of the motor industry has provided a new and more peaceful outlet. Aluminium is also employed in the manufacture of the explosive ammonal and the production of metallic paint. The aluminium-manufacturing industry may be divided into three parts: (1) Rolling and wire drawing are largely carried on in the metal-working district of south-west Lancashire (Warrington, Prescot, St. Helens, etc.); but the largest single establishment in the industry is the recent (1950) works at Rogerstone, near Newport, in South Wales, where a continuous rolling mill converts Canadian aluminium pig into saleable

products. In North Wales the Dolgarrog hydro-electric plant is concerned with sheet-rolling from imported ingots. Outlying centres, owing their origin largely to cheap land and good rail communications, are Banbury and Milton (near Stoke-on-Trent). (2) The foundry industry is much more scattered, but its correlation with the motor-car industry is most marked; the most important centres being Coventry, Birmingham (and various Black Country towns), Manchester, Luton, and the Glasgow district (cf. Chapter XVII, p. 417). It was natural, considering the importance of the Birmingham-Smethwick-West Bromwich area in the brass and iron-foundry trades, that the first establishment for making aluminium castings should have been set up at Smethwick in 1900. The growth

PRODUCTION AND EXPORT OF ALUMINIUM PRODUCTS, 1948

(Thousand Tons)

	Output	Export
Ingots, bars, billets, etc. (unwrought)	402	6
Tubes, bars, rods, plates, sheets, etc.	266	46

of the industry elsewhere is largely the result of the development of the motor-car and aircraft industries; (3) The hollow-ware trade, essentially a post-1918 development, is centred at Birmingham, where it is the logical successor of the decayed cast-iron hollow-ware industry.

A flourishing export trade in aluminium products has been built up since the Second World War (see tables on pp. 448, 457).

Lead.—With the decline of the home lead-mining industry, and the increase of lead smelting at the rich mines of foreign countries, Britain has lost the high position which she formerly occupied in the lead trade. The ores produced in this country now provide less than one per cent. of the total lead consumed, the remainder being imported chiefly in the form of pig-lead from abroad (see table on p. 445). To a greater extent than most other metals, lead is used in the production of certain chemical compounds as well as in the metallic state. Of these compounds the most important are white lead, red lead, and litharge. They are used in the manufacture of glass, for glazing pottery and earthenware, and for the manufacture of paints and pigments. In the metallic state (when it is soft though tough, flexible and very malleable) lead is made into sheets, pipes, wire, and shot; whilst alloyed with other metals it contributes to the production of type metal (lead and antimony), pewter (lead and tin) and certain kinds of brass. Considering this great variety of uses and also the

rather scattered nature of the old-time lead industry (cf. Fig. 214), it is not surprising that the manufacture of lead and its products should be much more widely distributed than most of the other non-ferrous metal trades. The only important lead-smelting establishments still using locally produced ores are in Derbyshire (near Matlock) and on Deeside in Flintshire (at Bagillt). The establishments on Tyneside which flourished in the days when the Alston Moor mines were at the height of their prosperity have now to rely on imported material; the cessation of Mendip lead mining has similarly left the Bristol works without their original basis. The total output of pig-lead from British smelters is now a mere 2–4,000 tons a year.

The most important centres of the lead industry to-day are to be found at the ports where the pig-lead is received. London,[1] Newcastle, Manchester, Bristol, and Glasgow are the most important, but as the raw material is imported in a refined condition, and so leaves little or no waste in manufacturing, numerous inland centres also have works devoted to the manufacture of lead sheets and pipes. About 20 per cent. of the pig-lead consumed goes towards the making of sheets and pipes, a further 25 per cent. is used in cable manufacture, and about 20 per cent. is employed in the production of white and red lead and litharge. The remainder finds an outlet in the manufacture of shot, batteries, solder, and type metal.

Zinc.—As with lead, the home production of zinc ores is now almost negligible, and the bulk of the requirements must be imported. In the case of zinc, however, considerable quantities of ore are still imported from Australia, as well as spelter, and smelting is thus still an important side of the industry, with an output of about 70,000 tons of metal a year. The chief uses of zinc are as follows: (1) We have already seen its importance in the brass industry, of which, with copper, it forms the raw material—about 40 per cent. of the spelter consumed goes towards the making of brass. (2) We have examined in Chapter XVII its use in galvanising steel sheets—about 20–25 per cent. of the spelter consumption is employed for this purpose. (3) Lastly, like lead, it has many subsidiary uses—in electric batteries and in the zincotype printing process, as well as (in the form of various compounds) for the manufacture of lithopone (used in the making of white rubber goods), in the production of pigments and varnishes, in the dyeing and calico-printing industry, and for medicinal purposes. Whilst zinc-using industries are scattered over many parts of the country, therefore, the existence of a large smelting industry, and the necessity for importing spelter as well are bound to have considerable effect upon their distribution.

The smelting of imported ores (i.e. the production of spelter) is carried on chiefly in Swansea, where the industry grew up very

[1] In 1931 a large works at Northfleet commenced refining pig-lead from the Mount Isa mines in north Queensland.

largely out of the declining copper trade. At first calamine and blende were imported from abroad or from Flintshire, but now the bulk of the supply consists of Australian concentrates. Bristol [1] (the earliest centre of the spelter trade in the country) and West Hartlepool also have smelting works. The galvanising industry has two branches: the first, allied to the tin-plate trade, deals with corrugated galvanised steel sheets for roofing and fencing purposes (see Chapter XVII); the second, with which we are concerned here, is independent of the tin-plate industry, and is concerned with the galvanising of steel sheets and their manufacture into articles and wares—cisterns, tanks, dust-bins, chimney cowls, hollow-ware, etc. It is true that some of the corrugated-sheet manufacturers of South Wales, Bristol, and Flintshire also deal in the second branch of the industry, but in the main this trade is concentrated in the Birmingham area and at certain ports. In Birmingham and the Black Country it is an offshoot of the formerly important tin-plate trade in an area which deals largely in zinc for its brass industry. At Liverpool, Manchester, London, and Glasgow, the localising factors would seem to be (*a*) the port where, in the course of general trade, spelter ingots are most conveniently imported, and (*b*) the presence in the vicinity of a large market for the type of goods produced.

The general working of zinc, apart from galvanising and brass making, is carried on in a large number of towns, but as with most of the non-ferrous metals, the industry is dominated by Birmingham, where over 40 per cent. of the firms engaged in the trade have their headquarters.

Tin.—Tin is not used in nearly such large quantities as lead and copper, the reason being that it does not enter into commerce in the form of articles made of tin, but is employed chiefly in the tin-plate industry (to the extent of about 60 per cent. of the total consumption), in the manufacture of numerous alloys, such as bronze (tin and copper) (*vide infra*) and its varieties—bell-metal and gun-metal, Britannia metal [2] (tin and antimony) and pewter (tin and lead), and in the formation of a number of useful chemical compounds, used especially in the dyeing and calico-printing industries.

Since the Cornish tin mines, like most other non-ferrous metal mines in Britain, now provide only a very small proportion of the total requirements, a large import of concentrates and metal bars is necessary. The tin-smelting industry is located chiefly at Liverpool (Bootle), but there is also a works at Northfleet, on the Thames below London. It is doubtful whether the Cornish smelters at Redruth will ever work again. The annual smelter output of metallic tin is of the order of 30,000 tons.

[1] National Smelting Co. at Avonmouth—erected by the Government during the First World War.

[2] Britannia metal is largely used in the manufacture of Sheffield plate.

Much of the bar tin imported is consumed in the tin-plate industry of South Wales (cf. Chapter XVII). The bronze industry is dealt with below.

Copper.—Copper was probably the first metal ever adapted by man for his own uses—but its importance in human affairs is now greater than ever before, owing to the part which it plays in the transmission of electrical energy. The valuable properties of copper are its great tensile strength, its ductility, which permits it to be drawn out into the finest of wires, and its capacity for conducting an electric current. The output of copper products in 1951 was 700,000 tons.

All the copper used in this country now has to be imported, and in consequence the location of the industry is but an interesting reminder of bygone conditions. The early copper industries were founded on such sound geographical bases, however, that the industrial inertia which they have accumulated has sufficed to maintain them, the only alterations being the substitution of refining for ore smelting, and perhaps some change in the nature of the output.

The smelting and refining of matte (half smelted copper) [1] is carried on in those two regions which were formerly dominant in the ore-smelting industry—south-west Lancashire and South Wales, Widnes and Port Talbot being the chief centres. Birmingham and Walsall also have smelting works. The refining and working up of imported copper bars and their transformation into rolled sheets and wire is an industry located mainly in South Lancashire (Widnes, St. Helens, Prescot,[2] Garston (Liverpool))—note the connection with the electrical machinery and cable industries—but several other places, such as Swansea, Glasgow, Hebburn-on-Tyne, Birmingham, Walsall, and Leeds, also share in this branch. About 30 per cent. of the total consumption of copper is employed in the production of wire, and another 25 per cent. in the manufacture of plates and sheets. The manufacture of copper tubes for boilers employs about 10 per cent. of the copper consumption. As far back as the 'sixties some 8,000–9,000 tons of tubes were being produced annually, and the growth of railways and steamships increased this quantity materially before the end of the century. The use of the superheater and of higher boiler pressures, however, with the employment of steel tubes, have done much damage to this section of the trade; and the demand for copper fire-boxes has likewise decreased with the substitution of steel. On the other hand copper

[1] Copper smelting is a more complicated process than iron smelting. The ore is roasted and once smelted to get rid of most of the sulphur (hence the sulphurous fumes mentioned above) and in this stage it is known as "matte" or "regulus"; a further roasting follows, and then another smelting, when the copper is ready for a final electrolytic refining.

[2] A new works was opened at Prescot in 1933 for the working of copper of great purity from the Roan Antelope mine in Northern Rhodesia.

pipes have largely replaced lead pipes in domestic plumbing. The tube industry is concentrated almost entirely upon Birmingham, where Boulton and Watt first began to produce steam engines on an economic scale in 1775.

Copper is second only to iron as a metal useful to industry, and of the immense variety of articles that can be stamped, pressed, or otherwise fabricated from copper sheets and bars, the electrical and the machinery industries employ the largest proportion. We may expect the "coppersmith" trade to be located, therefore, with special reference to these industries (cf. Chapter XVII) and it is not surprising that, as judged by the number of establishments, Manchester and Glasgow, the two greatest engineering cities in the country, should head the list. London, Birmingham, Liverpool, Sheffield, the textile engineering towns of the West Riding and south-east Lancashire, and the Tyneside towns are also important—but the industry, like general engineering, is on the whole very scattered.

The Alloys.—Alloys are mixtures of two or more metals designed to give physical properties different from those of the metals which compose them. Some of these have already been referred to. The most important groups are the brasses and bronzes.

Brass.—Brass is the name given to a whole series of copper-zinc alloys, containing over 50 per cent. of copper, the mixing of the metals in different proportions creating new metals of varying properties. Brass, like copper, will take on a brilliant polish, and has a similar high tensile strength, but it is harder than copper. Of the many different varieties in common use, the following may be cited as examples: "yellow metal" for hot stamping is 58:40 with a little lead; Muntz's metal, a malleable variety, is 60:40; brass for wire 70:30; "naval" brass 61:38, with a little tin to improve its corrosion-resisting property. It may be as well to remind ourselves of the many ways in which brass enters into commerce and industry. The brass trade falls naturally into two sections: (1) the actual making of the alloy and the production of semi-manufactured material. Of an annual production of something over 250,000 tons, about 90 per cent. is in the form of rods and sheets (the raw material of the foundry and stamping branches) about 5 per cent. is brass wire, and about 5 per cent. in the form of tubes (for boilers, bedsteads, and curtain rods); (2) the finished goods section, comprising cabinet brassfoundry (hinges, knobs, etc.), lighting (oil lamps, gas, and electric-light fittings), plumbers' brassfoundry (taps, etc.), engineers' brassfoundry (steam cocks, whistles, etc.) naval brassfoundry, and a host of general products, such as picture rails and nails.

The brass industry has many times, with changing fashions, been called upon to turn to new activities, and usually the decline of one branch has been accompanied or followed by the rise of another.

This has been especially evident during the present century. The declining demand for the elaborate gas fittings, ornamental candlesticks, brass-railed bedsteads, and brass hearth furniture of the Victorian era has been offset by the rise of the electrical and motor-car industries, both of which are great brass users, and by the great post-1918 development of housing schemes with their accompanying need for "builders' brassfoundry" (locks, hinges, knobs, rails, and so on).

The whole of the brass industry is dominated by Birmingham. At the 1931 census, of 40,000 people employed in the making of brass and brass-ware, over 16,000 were enumerated in that city, whilst several thousands more were not far away in Smethwick and the Black Country towns.[1] Outside the Birmingham region, the various branches of the brass trade are very widely scattered all over the country, most important towns, and many quite unimportant ones, having some establishment, possibly a huge factory or possibly only a small workshop, dealing with one or another type of product. Much of the heavy brass industry, together with naval brassfoundry, has migrated northwards to the engineering and shipbuilding centres, leaving Birmingham to specialise upon the innumerable smaller foundry and stamped products. Thus whilst Birmingham had only 30 per cent. of the brassfoundry workers in 1931, it claimed 62 per cent. of the workers employed in the manufacture of light brass goods (builders' accessories, etc.). The rapid development of plastics and stainless steel has had a very serious effect on the latter branch. In 1921 it employed 24,000 people; in 1931 only 12,000. The numerous engineering industries of London employ some 2,000 brassworkers, and Manchester, Glasgow, Wolverhampton, Liverpool, Leeds, Huddersfield, Sheffield, Rotherham, Newcastle, and Bristol—to name only a few—are amongst the most important provincial centres of the brass trade.

Bronze.—Bronze was the first alloy ever made. Although it is no longer the chief metal for ornaments, utensils, and weapons, certain types of bronze still play an important part in industry and art. Bronzes are harder, stronger, and more durable than copper or brass, and are particularly resistant to the effects of atmospheric weathering. In industry, bronzes are employed for machinery bearings, pumps, boiler-mountings, valves, and cocks, and for parts exposed to damp air or water; and in the arts, bronze is almost unrivalled for beauty of finish and general appearance in the production of statuary and ornaments. In general, bronzes are made up of about 80 per cent. copper, and 20 per cent. tin; gun-metal (so called because it was formerly a favourite material for the making of cannon) has more copper, and more recent varieties which give extra strength and toughness, combined with an even greater

[1] As the table on p. 457 shows, the position in 1950 was almost exactly the same.

resistance to corrosion, are phosphor bronze (containing some lead and a little phosphorus) and manganese bronze (with a little manganese and iron).

The chief centres of the bronze industry are Birmingham and London. Other towns of importance are Manchester, Coventry, and Glasgow (note the correlation with the engineering and motor industries), and Sheffield, where the industry is one of many concerned with non-ferrous metals (especially the rarer ones). The numerous other centres are scattered, and no geographical explanation can be given of them.

Other Metals.—Antimony, chromium, molybdenum, tungsten, bismuth, and other rarer metals are imported into this country in small quantities for special purposes—usually for alloying with other non-ferrous metals or with steel. Antimony is used, largely by reason of its hardness and resistance to corrosion, in Britannia metal and type metal; chromium, molybdenum, and tungsten are chiefly employed at Sheffield for the production of special quality steels—chromium for rustless steel [1] and steels of high-tensile strength, molybdenum for high-speed tool steels, tungsten for very hard steels (and also for wire in incandescent electric lamps). These metals are refined either at Sheffield, where their subsequent employment lies, or in south Lancashire (Widnes and St. Helens). Bismuth has the important property, which it also imparts to its alloys, of expanding when it solidifies from the molten state. When used as a constituent of type-metal it ensures a good sharp type if cast from moulds. The most important of the other metals, however, is nickel. Nickel matte from Canada is refined at Clydach (Swansea), and the resulting metal is employed in the manufacture of nickel-silver at Sheffield and Birmingham, and in the production of nickel-steel, a high-tensile variety, at Sheffield. An interesting by-product obtained at Swansea is copper sulphate (the nickel matte contains copper) exported to Mediterranean countries for vine spraying, and to Ireland for potato spraying.[2]

The Precious Metals.—Although gold and silver ores have never been worked in any great quantity in Britain, the unceasing demand for plate, ornaments and jewellery has given rise to a flourishing industry based upon imported supplies of these precious metals. In 1950, over 28,000 people found employment in the jewellery, precious metal working, and plate trades. This section of the non-ferrous metal industry is far more concentrated on a few localities than any of the trades devoted to the baser metals. Birmingham, Sheffield, and London are the only cities in which the precious

[1] Notice also the amazingly rapid recent growth of chromium plating.

[2] Production of copper sulphate (average, 1928–1931), 44,000 tons. Export of copper sulphate (average, 1928–1931), 43,000 tons. Since 1945 the annual export has fluctuated between 25,000 and 55,000 tons.

metals are utilised to any extent. Avoiding details, it may be said that Birmingham largely controls the refining and beating of gold, and the manufacture of gold chains and other jewellery, whilst silver and the electro-plating trades are divided between that city and Sheffield. The Sheffield silver-plate industry dates from about 1742, when Thomas Bolsover discovered a method of coating a copper ingot with silver in such a manner that it could be subsequently rolled and worked into plate and ornaments. The growth of the silver and electro-plating trades in Sheffield (the latter from 1840) is partly the result of this almost accidental beginning, and is partly, no doubt, to be ascribed to the availability of labour already skilled in the working of metals. Finally, London, largely by reason of its immense potential market, shares in all the chief branches of the gold and silver industry.

An attempt may now be made to summarise the non-ferrous metal industries according to the regions of Britain where they are carried on.

In 1950, nearly 170,000 people were employed in Great Britain in industries concerned entirely, or almost entirely, with non-ferrous metals. This figure differs little from that recorded in the Census of 1931, at which date about 49 per cent. were in Birmingham and the Black Country, 16 per cent. in the London district, 13 per cent. in the West Riding, and 8 per cent. in South Lancashire.

Although many branches, as we have seen, are very scattered in their distribution, the non-ferrous metal industry as a whole falls, geographically, into a number of fairly well defined provinces, each characterised by the presence of a different series of trades.

The *Birmingham District*[1] is probably the greatest metal-working area in the whole world. Employing nearly 70,000 people, it engages in almost every possible activity connected with non-ferrous metals, from smelting and refining, through the production of semi-manufactured material to the fabrication of innumerable varieties of finished goods. Its specialities, however, are the making of brass, the rolling of brass and copper, and the manufacture of tubes, the production of all kinds of cast and stamped copper and brass-foundry, the working of gold, and the manufacture of gold, silver, and electro-plated ware, and the production of aluminium hollow-ware.

The *London District*, including lower Thames-side, also has a great variety of metal trades, owing to the facility for importing raw materials and the extensive market provided by the eight millions of people in the conurbation. Northfleet has important tin and lead-refining works, and London itself, principally in the East End

[1] See "Birmingham and its Regional Setting" (British Association Handbook, 1950), especially pp. 159–248; also M. J. Wise, "The Evolution of the Jewellery and Gun quarters in Birmingham" *Inst. Brit. Geog.* 15 1949, 58–72.

and also south of the Thames, engages in the jewellery trades, sheet-metal working of all kinds, brass and copper foundry, bronze manufacture, galvanising, and the manufacture of lead, and lead products.[1]

The *West Riding* assumes a position of importance, largely by reason of the part played by Sheffield in the manufacture of silver ware and electro-plated goods. The baser metals are also worked to a considerable extent, however, notably copper and brass—these industries, located mainly in the towns which make up the West Yorkshire conurbation, as well as in Sheffield, being dependent upon and auxiliary to, the great engineering industries of that region.

South Lancashire has two sides to its industry. In the western part of the region, at Liverpool, Widnes, and St. Helens, are located the smelting and refining branches, together with rolling and wire drawing, the chief metals dealt with being copper, tin, and aluminium. The eastern part of the region, however, is more concerned with copper and brassfoundry as a part of the great engineering industry of Manchester and the other towns that have been mentioned in Chapter XVII.

In *South Wales* we find all that remains of the once world-famous smelting industry. In the Swansea-Port Talbot area are the principal zinc and nickel smelters in the country and the last remnant of the Welsh copper-smelting trade. It is a good reflection upon the geographical environment of South Wales, however, that just as in the iron trade, few or no derived industries should have been set up. The absence of a great engineering industry has rendered impossible the growth of extensive foundry trades, and even rolling and wire drawing are conspicuous by their absence or feeble development. The Newport district has only recently become associated with non-ferrous metals, and the development of its now flourishing aluminium industry dates mainly from the Second World War and after. The smelting and refining industries at Bristol may be considered, having similar geographical bases, as an outlier of the South Wales province.

The *North-east Coast* still retains its interest in the smelting business, lead and zinc being produced from materials which now have to be imported. The brass and copper industries are largely bound up with the engineering and shipbuilding trades, being concerned primarily with the requirements of the shipyards, and the marine and locomotive engineers.

On *Clydeside* the non-ferrous metal industries are mainly dependent upon the engineering and shipbuilding trades, but they also owe their development partly, as at other large ports, to the facility for importing raw materials. Copper and brassfoundry,

[1] Billiter Street, in London (bellyeter = bell-founder), was a former centre of the bell-founding trade. London has 300 foundries dealing with non-ferrous metals.

sheet-metal work, jewellery, and galvanising are the most important branches.

EMPLOYMENT IN NON-FERROUS METAL INDUSTRIES, 1950 [1]
(In Thousands)

Region	Smelting, Refining, Rolling	Brass Industry	Jewellery and Precious metals	Total
Scotland	6·4	2·2	0·2	8·8
Wales	11·0	0·4	0·5	11·9
Northern	2·5	1·5	0·0	4·0
North-west	9·2	2·6	0·5	12·3
E. and W. Ridings	5·4	5·5	5·4	16·3
N. Midlands	0·6	0·4	0·0	1·0
Midlands	37·5	21·6	10·8	69·9
South-west	2·7	0·3	0·0	3·0
South	7·3	0 4	0·2	7·9
East	2·7	0·3	0·1	3·1
London and S.E.	13·9	4·6	10·8	29·3
(London)	*13·0*	*4·6*	*10·5*	*28·1*
Total	99·1	40·0	28·6	167·7 [2]

[1] Compare table on p. 427, in which the same regional divisions are used.
[2] Compare 1921, 181·6; 1931, 147·5.

EXPORTS OF NON-FERROUS METALS AND MANUFACTURES THEREOF
(Thousand Tons)

Metal	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Aluminium	—	5·9	9·6	6·8	7·9	69·6	58·6
Brass	13·4	26·2	21·3	12·1	25 9	65·1[1]	55·9[1]
Copper	63·4	32·3	33·7	19 4	38·9	58·0	48·7
Lead	48 4	18·0	12·2	9·3	12 0	3·7	4·8
Nickel	—	4·6	7·8	4·8	11·7	17 0	13·8
Tin	11·5	18·8	29·3	25·0	25·4	4·2	15·4
Zinc	11·1	6·3	6·5	6·5	9·0	5 9	5·9
White Metal	—	6·9	4·0	3·8	3·9	2·0	3·5
Total value (Million £'s)	12·0	14·4	17·2	6·9	14·1	47·7	57·5

[1] Includes other copper alloys (other than nickel alloys).

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CHAPTER XIX

THE TEXTILE INDUSTRIES: WOOLLEN AND WORSTED[1]

The Textile Industries: General

THE textile industries, which for many centuries were the mainstay of British prosperity, are well supplied with literature, technical and historical, economic and geographical. In this and the following chapters little more can be attempted than a summary of the main features of their development, present distribution, and relative importance.

Not only are the textile industries of vital importance in employment and in foreign trade,[2] but they also provide interesting examples of the factors influencing the localisation of industry and the alterations in distribution brought about by changes in geographical values. These changing values are concerned primarily with the development of machinery and sources of power supply, and with the relative part played by the various kinds of raw material.

Although wool was from time immemorial the principal fibre employed in the making of cloth, the cotton industry, only introduced into Britain in the seventeenth century and not really important until the second half of the eighteenth, has long since surpassed the woollen in size; and whereas the making of woollen cloth, formerly a very scattered trade based upon local raw materials and still carried on in a number of different areas, has suffered radical changes in its geographical distribution, the cotton industry, never very widespread and always using imported fibre, has been localised very largely in the region of its origin. Of the industries based upon the minor textile fibres, those of long standing, such as linen and hemp, show very definite localisation upon home sources of raw material. The newer introductions, rayon and nylon, are essentially chemical industries as far as the production of fibre is concerned, but their utilisation has attached itself as a satellite to the older textile trades in regions where a "deposit" of labour skilled in the working of textiles had accumulated.

[1] By S. H. Beaver. The authors were greatly indebted to their colleague, Mr. H. L Beales, for his valued comments on this chapter in its original form.

[2] Percentage of total value of U.K. exports, 1950 (1913 figures in brackets): woollen mfs., 6·6 (8·0); cotton mfs., 7·3 (25·6); linen mfs., 1·4 (1·9); silk mfs., 2·3 (0·5).

EMPLOYMENT IN THE TEXTILE INDUSTRIES

Industry	1924[1]	1930[1]	1950[2]
Cotton	526,110	379,234	326,500
Wool and worsted	273,297	222,963	215,700
Fellmongery	2,405	2,358	1,615
Hemp and linen	24,547	15,759	14,000
Textile finishing[3]	108,397	98,239	89,500
Canvas and sacking	8,680	7,088	—[4]
Silk and artificial silk	39,932	59,540	50,100[5]
Lace	17,334	14,123	13,400
Hosiery	95,529	96,619	123,100
Total	1,096,231	897,923	1,013,200

[1] Census of Production Reports. [2] Ministry of Labour figures.
[3] Bleaching, dyeing, printing, finishing. [4] Not available.
[5] Includes rayon and nylon *weaving*; rayon and nylon *production* employed 47,300 in 1950 (cf. p. 536).

The Historical Geography of the Woollen and Worsted Industries[1]

From the twelfth to the nineteenth centuries the woollen industry was the premier English industry, and as such was largely responsible for the growth of the country's wealth and so for the accumulation of the capital which has rendered possible the development of the homeland and the Empire. Thus the existing industry is but the result of many centuries of development in which geographical factors have played a very large part.

(*a*) *From the earliest times to the fourteenth century.*—It is probable that a primitive domestic woollen industry existed even before the Roman occupation, and it is certain that cloth was made in Britain during that period, for the Romans had an establishment at Winchester for making fine uniform cloths, and evidence of dyeing and fulling operations has been found at various places in southern England. Spinning and weaving are occasionally mentioned in Anglo-Saxon literature, and it is possible that woollen fabrics were being exported to the Continent as early as the eighth century. Not until after the Norman Conquest, however, do we see definite evidences of the growth, helped probably by the skill of artisans amongst William's followers and by numerous refugees from continental wars, of a flourishing industry. This industry in the twelfth and thirteenth centuries was to be found principally in the larger towns of the southern and eastern parts of the country, which,

[1] Of the mass of historical literature, one of the most valuable items is E. Lipson, *History of the English Woollen and Worsted Industries*, 1921 (especially Chapter VI). The descriptions to be found in Leland's *Itinerary*, Fuller's *Church History*, and Defoe's *Tour of Great Britain* are exceedingly interesting and valuable as giving an account of the distribution and state of the industry at the different periods when they were written.

largely owing to their accessibility from the Continent and from the Metropolis, were at that time the seat of the chief economic developments. The earliest recorded weavers' guilds, for example, grew up in London, Winchester, Lincoln, and Oxford, and other towns which gained a reputation for fine wares were York, Beverley, Colchester, and Sudbury. Although the making of cloth was widespread, however, the industry was probably of no great magnitude, and most of the wool from the English sheep was exported in a raw state to the Continent.

(*b*) *The first economic revolution, fourteenth to sixteenth centuries.*—Having reached a peak of production and export in the thirteenth century, the wool trade declined for a long period; the almost incessant political strife was not conducive to its expansion, and many formerly important centres decayed. The seeds of a new period of progress were sown in the fourteenth century, however, when, from 1331 onwards, small bands of skilled craftsmen from Flanders were encouraged to settle in various parts of the country. Numerous weavers, dyers, and fullers settled in large towns where the woollen industry was already in existence—such as London, York, Winchester, and Norwich—or scattered themselves over the countryside. The widespread possibilities for cloth-making were largely due to the suitability of such large areas of the countryside for sheep rearing (although from the earliest times the drier limestone and chalk uplands seem to have been the chief regions), and the absence of other localising influences. Water-mills were only just coming into use for working the fulling hammers,[1] and not only was the power required so small that almost any stream would do, but the unfinished cloth could be, and indeed was, sent from scattered weavers' houses to the small streamside establishment of the fuller.[2]

The export trade in wool recovered; it was largely a seasonal trade, for before the introduction of root crops as fodder, large numbers of animals had to be slaughtered in the autumn. Thus in the summer the shorn wool was sent across the Channel, in the autumn and winter the "fells"—skins with wool still adhering thereto. But manufacturing expanded as well, and gradually the cloth industry began to be more localised and rather more specialised. The need for soft, lime-free water for the washing, scouring, and dyeing processes, combined with the increasing use of water power for the fulling mills, resulted in certain regions offering a more than usually favourable environment for the industry. In Gloucestershire, Somerset, and Wiltshire, the importance of the sandstone formations in the Jurassic series, as suppliers of soft water, and the

[1] R. A. Pelham, "Distribution of Early Fulling Mills in England and Wales," *Geography*, XXIX, 1944, 52–56.

[2] The need of pure water for dyeing was not apparent whilst most of the cloth was exported in a "grey" state to be finished in Flanders.

existence of a dissected scarp, providing numerous power sites, together with the extensive sheep pastures on the Cotswolds and in Herefordshire, were favourable factors. In Devonshire a number of centres grew up on the outer edges of the Dartmoor mass, favoured by soft water from the granites or culm measures and a useful power supply. In the Pennine districts of Yorkshire and Lancashire the soft water from the Millstone Grit uplands and the numerous steeply-graded streams gave plenty of scope for development. In East Anglia, where many of the Flemish weavers settled, much soft water was available from the Boulder Clay streams, but little or no power. As a result, this region was not so well fitted for the production of true woollen goods, and came early to specialise in the manufacture of worsteds.[1] The idea of the fulling operation was to felt the cloth by pounding it with hammers in water mixed with soap or fuller's earth, and as worsted fabrics made from longer and finer wools did not require this treatment, power was not necessary. Of these four areas the two in the west of England were producing, at the end of the fifteenth century, about one-third of the woollen cloth made in England, East Anglia was responsible for about a quarter and Yorkshire for one-eighth (mainly of poor quality), and, in addition, East Anglia produced almost all the worsted material. Finally, it is very noticeable that the sheep-rearing regions of the Jurassic scarplands where limestone is a dominant formation and the stream water consequently hard—*e.g.* Lincolnshire and Northamptonshire —did not develop the manufacture of woollen fabrics to any great extent.

Thus during this period the whole economic outlook of the country was changed, and from being primarily an exporter of raw wool England became in addition a manufacturer and exporter of cloth. The end of the fifteenth century saw England "largely a nation of sheep-farmers and cloth-makers." The wealth derived from the wool trade was spent in church building and road-making, and many a fine church and cathedral and many a now-ruined abbey owes its origin to the sheep. The monks especially were great sheep farmers, as the records of the many old abbeys of Yorkshire bear witness.

(*c*) *Growth and expansion, sixteenth to eighteenth centuries.*—The expansion of the woollen and worsted industries brought about an increasing specialisation: (i) of different regions in different classes of goods; (ii) of individual members of a manufacturing community in different processes; and it also contributed to the rise of a new class in society—the "clothiers" or "drapers" who purchased raw wool from the farmers, gave it out to the spinners and weavers to be

[1] It is generally agreed that the name "worsted" is derived from the little village of Worstead, not far from Norwich, one of the earliest centres of the industry.

made into cloth, and then sold the finished pieces in local markets or at the London Cloth Fair.[1] Much of the wealth gained by the drapers, and by the companies which they formed, went not into ecclesiastical channels but towards the further expansion of industry and trade. Then political and religious troubles on the Continent were continually interfering with the Flemish cloth industry, and from time to time bands of refugees would flee their country and settle in England. In the sixteenth century, for example, after the revocation of the Edict of Nantes, a large body of Huguenots arrived from France and took up their abode in various cloth-making regions, notably in the Stroud area of Gloucestershire. As a result, the English cloth trade began to surpass that of Flanders, and at the end of the seventeenth century woollen manufactures made up two-thirds by value of England's export trade.

We must pause to analyse in a little more detail the geographical background of the principal centres of the industry in the seventeenth and early eighteenth centuries.

1. *The West Country.*[2]—Within the region so designated there were two distinct producing districts, the Cotswold area (extending from Cirencester to Sherborne, and from Devizes to Bristol), and Devonshire. In Gloucestershire, Wiltshire, and part of Somerset was concentrated the manufacture of the famous "broadcloths," whilst Devonshire and south-western Somerset specialised in serges. The geographical advantages possessed by the region as a whole may be summed up as follows:

(1) The agricultural wealth of the fertile vales and the pastoral wealth of the uplands had long been utilised and had given rise in quite early times to a comparatively dense population.

(2) Supplies of raw materials—long-woolled sheep of Dartmoor and the Cotswolds (for the serge industry), short-woolled sheep of the near-by chalk uplands and the rich lands of Herefordshire, of the Forest of Dean and of Exmoor, and fuller's earth from the local "Fuller's Earth" formation, which is particularly well developed on the dip-slope of the Cotswolds—were present in abundance.

(3) When the necessity arrived, the geographical situation for the import of foreign wool was distinctly favourable—and Barnstaple and Bristol imported long wools from Ireland and fine merino wool from Spain.

(4) The abundance of soft water,[3] which was particularly

[1] The markets were known as "Cloth Halls"—*e.g.* Blackwell Hall in London.

[2] See R. H. Kinvig, "Historical Geography of the West Country Woollen Industry," *Geographical Teacher*, VIII, 1916, pp. 243–254; 290–302.

[3] Although much of the Cotswold dip-slope plateau is composed of shelly limestone (known as "calcareous grit"), the chief water-bearing bed in the Scarp region is the Cotswold (or Midford) Sand, which yields copious supplies having a very low degree of permanent hardness.

suitable for dyeing, and of small water-power sites, as mentioned above, rendered the localisation complete.

Broadcloth was, perhaps, the finest variety of woollen fabric ever produced. It was made from the best short wools (*i.e.* not from the local Cotswold sheep) and was heavily fulled and felted so that when finished the weave was quite invisible. It was used for uniforms, liveries, and the best class of clothing. The wearing of broadcloth was formerly the mark of a gentleman. The importance of a power supply for the fulling is very evident, and it is not surprising

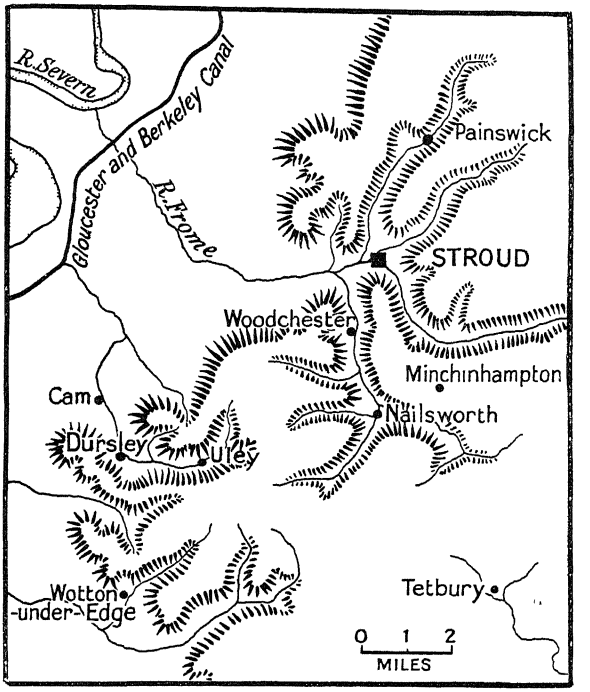

FIG. 215.—The Broadcloth Region in the Dissected Scarpland of the Cotswolds

that with the growth of the industry the localisation became more definite, and the network of "clothing towns" and "clothing villages" which Leland describes became more concentrated. The early town centres, Gloucester, Bristol, and Tewkesbury, soon declined, and the less suitable outlying centres as, for example, the villages along the chalk scarp (Devizes, Warminster); those on the Mendip fringe (Frome, Wells); those on the Jurassic scarp of Somerset (Bruton, Castle Cary) and those in the Avon valley (Chippenham, Melksham, Bradford) decreased in importance or became specialised. Wells, for example, took up the hosiery trade; Frome specialised in fine

Spanish cloths. It was on the dissected west-facing scarp of the Cotswolds that the industry became concentrated, and the old centres on the dip-slope—Tetbury, Cirencester, and Witney—all had to specialise to avoid extinction. Thus Tetbury, devoid of water power (almost, in fact, devoid of water), took up wool-combing and spinning, and Cirencester did likewise—thin yarn from the long-woolled Cotswold sheep being sent to the hosiery and worsted centres. Witney, partly perhaps owing to a peculiarity of the Windrush water which makes it well suited to the bleaching operation and partly to the fact that it had little or no power, specialised in blankets, which are made from short wool and fells and do not need heavy milling. On the western slope of the Cotswolds the deeply cut valleys of the Frome and its tributaries contained numerous centres of the industry—Stroud, Painswick, Minchinhampton, Woodchester, and Nailsworth, and a little further south the edges of a westerly projection of the scarp provided power sites, for example, at Dursley, Wotton-under-Edge, and Uley (Fig. 215). The waters of the scarp were considered to possess some property which rendered them particularly suitable for the production of the fine scarlet dye for which Gloucestershire cloths were famed.

"Serge" was the name given to a fabric made with a warp (longitudinal threads) of long wool, and a weft (crosswise threads) of short wool (or of the short combings derived from the long wool). Both long (Dartmoor) and short (Exmoor) wools were available in Devonshire, and in addition much long Irish wool was imported *via* Barnstaple and other ports, and short wool from Kent and Sussex, *via* Exeter. Water power was necessary for milling serges, as for broadcloths, and the numerous small streams radiating from the Dartmoor massif supplied this in plenty. But owing to the comparative isolation of the individual streams many small manufacturing centres grew up, and there was no concentration as at Stroud. Ashburton, Buckfastleigh, Tavistock, Okehampton, North and South Molton, Tiverton, and Crediton may be cited as examples, whilst just over the border, in Somerset, Taunton and Wellington were also engaged in the serge trade (Fig. 216). The great market for all this industry was Exeter, which in the eighteenth century rivalled Leeds in this respect.[1]

2. *East Anglia*, lacking water power, obviously could not produce broadcloths and serges, and in consequence it was the worsted trade which flourished here. The world-wide fame to which this region attained in the seventeenth and eighteenth centuries was in large measure due to the presence of the Flemish weavers and their

[1] See W. G. Hoskins, *Industry, Trade and People in Exeter, 1688–1800*, Manchester Univ. Press, 1935. Chap. II gives an account of the serge industry, which about 1700 was the most important branch of the national woollen manufacture, accounting for over a quarter of the total exports.

descendants—for far more artistic skill was necessary for the production of patterned worsteds than for the making and finishing of plain broadcloths. Two separate districts were engaged in the trade. Norwich, once the greatest manufacturing town in all England,[1] was the centre of a whole group of flourishing towns and villages engaged in the production of fine worsteds: for example, Thetford, Diss, Dereham, and Attleborough. In Suffolk and Essex a number of

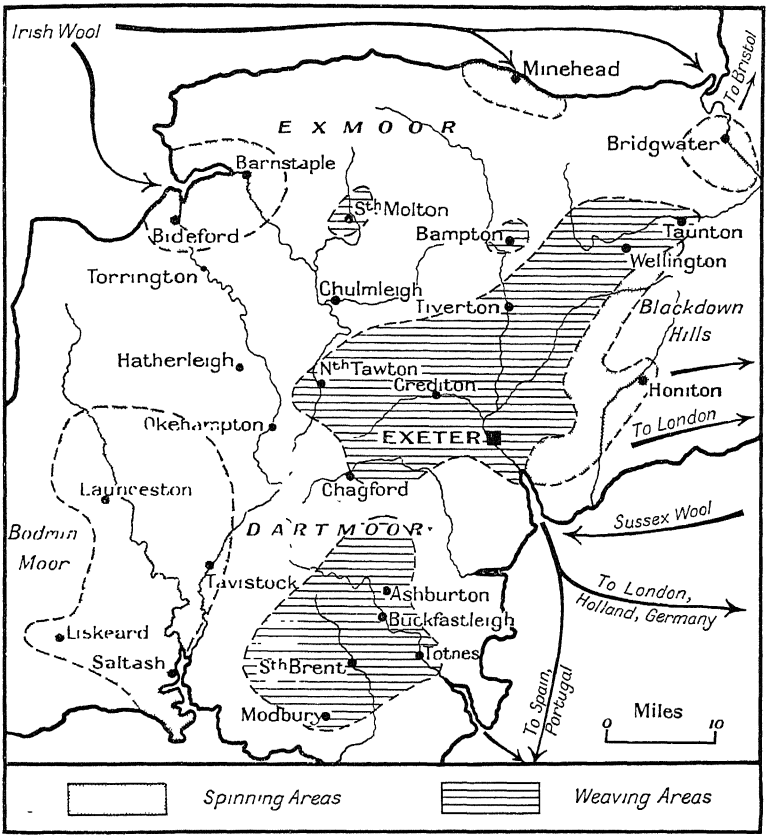

FIG. 216.—The West Country Woollen Industry about 1700. (Mainly after Hoskins)

towns in or near the Stour valley, the largest of which were Colchester, Sudbury, and Halstead, had a two-fold interest. Besides making some worsteds, and doing a great deal of combing and spinning for the Norwich weavers, this region, largely owing to the presence of a small amount of water power provided by the Stour and its tributaries, was devoted to the production of coarse cloths

[1] In 1770 no less than 72,000 people were employed.

made from short wools—baize and kerseys, which were not true woollens, but rough loose fabrics which did not need much milling.

For 400 years East Anglia possessed a virtual monopoly of the worsted trade, and not until the beginning of the eighteenth century did a rival appear in the West Riding of Yorkshire.

3. *Yorkshire and Lancashire.*—The gradual rise of the north country in the woollen trade is to be associated with the natural suitability of parts of the Pennines for sheep rearing, the abundance of lime-free water, and the existence of innumerable possible sites for waterwheels. The sixteenth-century spread of the industry up the valleys was also due to a country-ward movement of the crafts men away from the guild-fettered corporate towns of the lowlands.[1] We must not neglect the fact, also, that a good deal of energy behind the expansion of the industry came from the Nonconformists, whose Puritanism, with its insistence on the duty of work, its teaching that business could be a "divine calling," and its inculcation of the virtues of prudence, probity, and economy which smoothed the path to riches, was largely responsible for their accumulation of capital and its application to the development of trade. In both Lancashire and Yorkshire the early industry, devoted to the weaving of coarse woollen cloths called "kerseys," clung to the upper parts of the valleys, the dwellings where the spinning and weaving were done being situated on the slopes and higher parts (since surface water is very abundant on the Millstone Grit formation and Lower Coal Measures), the fulling mills in the valley bottoms by the larger streams. It was essentially a rural organisation—a combination of domestic industry and agriculture for the home food supply, where each house had its own cultivated patch and urban centres were not developed to any great extent.[2] The industry quickly outgrew the local wool supplies, and the Lancashire region began to import from Ireland and from the Midlands, whilst the West Riding came to rely more on Lincoln and Leicester wool. About the end of the sixteenth century, the manufacture of baize (using woollen warp and worsted weft) was introduced; but as the use of cotton began to spread soon afterwards in South Lancashire, the woollen trades in that area were pushed further and further eastwards until the Rochdale neighbourhood was the only important district remaining. Then, early in the eighteenth century, the wealthy merchants began to introduce the manufacture of worsted material, and Halifax and Rochdale quickly took to the making of "shalloons" (light worsted cloth for dresses and linings)—the older baize trade gradually dying or being replaced by the weaving of flannels. By the 1770's the output of worsted

[1] Of the great West Riding towns, only Wakefield ever harboured the guild system. The serious decline of York at this period is well known.

[2] See the illuminating description in Defoe's *Tour through the Island of Great Britain* (which covers the years 1724–1727).

cloth from the West Riding equalled that of Norwich, but the Yorkshire worsteds were mostly of much poorer quality.

An important auxiliary industry in the West Riding was the manufacture of wool-cards—stiff wire brushes used for opening out the wool and interlacing the fibres as a preparatory to spinning.[1] This was located at Brighouse—attracted thither by the old iron forge at Colne Bridge (near the outcrop of the sulphur-free "Better Bed" coal and near a formerly important seam of ironstone).

In the eighteenth century the main outline of the great conurbation was complete; Leeds, Bradford, Halifax, Huddersfield, and Wakefield were flourishing towns, Leeds and Wakefield having large cloth markets. Bradford had, however, not yet assumed special prominence.

4. Mention must finally be made of a few other isolated and rather specialised centres of the woollen industry. Worcester and Kidderminster were really outlying centres of the West Country broadcloth trade. Kendal, in Westmorland, was long famous for "Kendal cottons" (not made from cotton, but from local wool). In Leicestershire the local long-woolled flocks gave rise to a small woollen industry as early as the thirteenth century; and in the seventeenth century a domestic hosiery industry became established.

In the first half of the eighteenth century we thus see the woollen and worsted industries considerably more specialised and concentrated upon a few areas than they had ever been before. The West Country and East Anglia had almost reached their peak of prosperity, but the West Riding was really only just beginning to be of real importance in the manufacture of any but the poorest cloths. All this was about to be changed, for with the introduction of machinery and the utilisation of steam power and so of coal, the whole basis of the industry was radically transformed.

(*d*) *The Industrial Revolution*, 1750–1850.—The domestic processes of cloth manufacture had been little changed since the great revival of industry in the fourteenth century, and consequently the inventions which we have now to discuss produced an upheaval of unparalleled magnitude. This upheaval, however, took place earlier and was far more sudden in the case of the Lancashire cotton industry than with the Yorkshire woollen and worsted trades: in the first place because almost all the inventions emanated from Lancashire; secondly, because the woollen fibre did not lend itself so readily to being worked by fast-moving machinery; and thirdly, because an adequate supply of raw wool was not easy to obtain until Australian produce became available after about 1830. The history of these inventions is an oft-told tale, and a very brief summary must here suffice. In 1733 John Kay introduced the flying shuttle, thus rendering the process of

[1] The name "card" is derived from Latin *carduus* = a thistle or teazel, since teazel heads were used in the carding process.

weaving rather more rapid. This was perhaps a little unfortunate, for already it took ten spinners to keep one weaver supplied with yarn (a fact which is reflected in the large number of women who were engaged in spinning—and thus in the retention of the term "spinster" for an unmarried woman); in the 'seventies, however, Hargreaves' Spinning Jenny and Arkwright's roller-spinning machine remedied this state of affairs, and the application of water power to the latter resulted in such an increased output that a surplus of yarn was produced. The application of mechanical power to weaving was somewhat delayed (*vide infra*). All these inventions were applied first to the cotton industry and their adaptation to wool and worsted came later. As a result the "water-power" stage in the West Riding was not of long duration and in some cases did not exist at all—for by the time machinery was introduced on a large scale, the steam engine had been sufficiently perfected as to be the obvious source of power for new mills and new machines. A new control—the existence of productive coal measures—entered the field.

The Lancashire inventions gradually crossed the Pennines and worked their way into the West Riding from the south-west, *via* Huddersfield and Halifax, and probably by 1780 the use of the spinning jenny, still worked by hand, and of the scribbling machine (performing part of the carding process), worked by water power, had spread over most of the region. Neither of these could produce much change in the industry apart from a speeding up of certain of its processes—and by the separation of the upland, domestic, spinning and weaving from the valley-bottom scouring, fulling, and carding, much wasteful carriage had to be performed, each piece of wool journeying several times up and downhill before it finally emerged as a finished cloth. From 1785 onwards Watt's steam engine began to be used in the mills of Lancashire and Nottinghamshire, and the first in Yorkshire was set up for driving scribbling and fulling plant at Leeds in 1792[1]—marking the beginning of the end of the short reign of water power. Spinning machinery was introduced into Yorkshire in the 'nineties, and was in fairly general use by about 1810—the quick change-over being due possibly to the large numbers of women and children employed who were unable, like their men-folk, strenuously to resist the introduction of mechanical appliances. It must be noted, however, that it was the worsted branch, in which the longer, silkier fibres were more adaptable to mechanical handling, that progressed most, little headway being made with spinning machinery in the woollen branch until after 1830. Other, more commercial, reasons for the greater mechanisation of the worsted industry, were the greater capitalisation and more efficient organisation (it being a younger industry and

[1] See *Leeds Woollen Industry, 1780–1820.* Editor, W. B. Crump. (Thoresby Society, Leeds, 1931.)

essentially the product of Yorkshire's own accumulated wealth) and the large "outside" demand (from the East Anglian worsted trade and the hosiery trades) for worsted yarn. The introduction of power looms took a much longer time, partly owing to the technical difficulty already alluded to and partly owing to vigorous opposition from the hand-loom weavers. Not, in fact, until the early 'thirties was real progress made, but by 1835 Yorkshire possessed over 4,000 woollen and worsted power looms out of a total for the country of about 5,400 (a further 1,100 being only just across the Pennines in Lancashire).[1] Gig mills (rotating drums set with teazels for raising the nap on cloth) and shearing frames (for cropping the nap) were also introduced fairly late, and the famous Luddite Riots of 1812 were largely directed against their use. In the following decade, however, they were erected rapidly in all districts.

Even when, stimulated by the outstanding success of the mechanised cotton industry of Lancashire, the use of machinery was well established, wool continued to lag far behind worsted for reasons given above, and also because there was much less specialisation in the woollen trade, most factories completing all or most of the processes, and a considerable amount of domestic work still taking place. In 1835 the number of looms weaving worsted cloth was four times the number weaving wool, and as late as 1856 only half of all the woollen workers in the West Riding were employed in factories, and hand-loom weavers remained an important section until the 'seventies, not being finally negligible until about 1900.[2]

If the introduction of machinery was slow, though comparatively unobstructed, in the West Riding, it was much more retarded and much more bitterly opposed in the West Country, and in East Anglia the industry died before the machine had time to take root. Both in the West Country and in East Anglia the workers in the ancient industries were well organised and the industry was fairly concentrated, and so a much more effective opposition could be raised to the introduction of labour-saving machinery. This opposition proved their undoing. The swamping of the cloth market by cheap machine-made goods from Yorkshire gave a blow to the older industries from which they never recovered. The copying by machinery of all the fancy worsted designs of Norwich effectively killed the trade in that town. By 1830 domestic spinning had ceased to exist, and in 1838, when Yorkshire had 347 steam-driven mills employing over 26,000 people, Norwich had three with only 385 workers. The perfection of Arkwright's combing machinery had

[1] Compare this total with the 114,000 power looms which existed in the cotton industry at the same period.

[2] Persons employed in woollen and worsted factories: 1835, 55,461; 1850, 154,180; 1861, 173,046; 1870, 238,503; 1880, 301,556; 1901, 259,909. Cf. cotton, p. 497.

allowed short wools as well as long to be used for worsted manufacture, and the rapid spread of new fabrics produced by adding cotton, alpaca, or mohair warps to the worsted weft gave a tremendous stimulus to the Yorkshire worsted industry, which rapidly outpaced the slower growing woollen trade.

The West Country industry did not feel the pressure of Yorkshire competition so soon as East Anglia, owing to the late introduction of machinery and steam power into the woollen branch and to the persistence of the domestic system. After 1840, however, the declining market for the fine broadcloths and the inability of the Cotswold industry to adapt itself rapidly to the new conditions resulted in a period of decline—though the industry was by no means completely extinguished.

The general features of the Industrial Revolution period in the woollen and worsted industries may be summed up as follows:

(1) A gradual decline of the domestic system, less rapid in wool than in worsted, and in weaving than in spinning: accompanied by the development of large-scale production in factories.

(2) A short period of water power quickly followed by the employment of the steam engine for driving machinery.

(3) The rapid expansion of industry in the West Riding, where the localisation was confirmed by the presence of coal, which was employed for generating power and for heating and humidifying the mills in accordance with the requirements of the spinning and weaving operations.

(4) The rise to supremacy of worsted over woollen in Yorkshire very largely for technical reasons and owing to the organisation of the worsted industry.

(5) The decline and complete extinction of the Norwich worsted trade and the general decline of the West Country industry, where, however, with increasing specialisation the finest woollen cloths continued to be made.

(6) The growth of the West Riding, in combination with the rapid expansion of industry and population in Lancashire (see Chapter XX), brought about a change in the "centre of gravity" of the English population and an increasing dominance of the north over the south.

(*e*) *Modern Concentration and Development from* 1850.—The essential features in the geography of the woollen and worsted industries have remained unchanged since the great transformation wrought by the Industrial Revolution, and it remains to notice only the more important economic changes which have taken place.[1]

Despite the great increase in the productivity of the industries there has been little expansion since 1850 in the number of people

[1] See *Survey of the Textile Industries.* H.M.S.O., 1928.

employed.[1] This is of course due to the increased mechanisation of the various processes of manufacture, to the greater concentration in large factories, and to the improvements in speed and efficiency of the machines. During the present century there has been a marked tendency for steam power to be supplanted by electricity.[2]

Of the changes within the industry, the most notable is that wool has regained the position which it lost to worsted during the first half of last century. Within the worsted branch, the spinning section has developed more than weaving, for an increasing amount of yarn has been needed by the hosiery trade and a considerable export has been maintained.

Finally, the last hundred years have witnessed important changes in the source of our raw wool supply, which we must now proceed to analyse. In the second quarter of last century about three-quarters of the wool used was home grown, the remainder being fine Saxon and Silesian varieties. Between 1830 and 1860, however, Australian and Cape wools began to displace all other imports, and with the expansion of the industry the home clip began to assume a less significant position, until at the present time that part of it which is retained in Britain represents only about one-fifth of the total quantity used.

Raw Materials

The raw materials of the woollen and worsted industries consist principally of the wool of the domestic sheep, which is the most important of all fibres of animal origin used in the textile industries. There is no wild sheep with a fine fleece, and the sheep—now the most numerous of all domestic animals—was bred by man at an early date in the civilisation of the world. Even before the wool was used in weaving, sheep skins formed a valued protective covering. The fibres of wool differ from those of cotton in being covered with tiny overlapping scales, and the presence of these scales accounts for the "felting" properties of wool: the fibres can be beaten together

[1] *Ibid.*, p. 271. The number fluctuated around 260,000 until the 1920s, since when it has declined somewhat (see table on p. 459).

[2] Power employed in woollen and worsted industries (Census of Production):

	1924	1930
Prime movers (*i.e.* steam engines and turbines)	445,000 H.P.	402,000 H.P.
Electric generators driven by prime movers	73,000 kW.	91,000 kW.
Electric motors and purchased current	152,000 H P.	184,000 H.P.

At the Census of Production, 1948, the woollen and worsted industries were recorded as spending £3·6 mn. on coal and £1·17 mn. on electric current.

into a fabric (felt) without weaving because the scales interlock. It is because the fibres of wool are usually finely curled or crimped that a woollen cloth includes a large proportion of air space. Air is a bad conductor of heat and thus woollen clothes, with their large amount of included air, are very warm.

Without attempting to account for their origin, it may be said that wool-bearing sheep at the present day fall into three main groups:

(*a*) Original English breeds. In the Middle Ages wool was not only an important product but a leading export of England. The English breeds have become widespread in South Africa, Australia, and New Zealand. The animals thrive in cool, comparatively moist climates.

(*b*) Merino sheep. These sheep are natives of North Africa, but were introduced into Spain and other grassy areas in Mediterranean lands in the Middle Ages and later into Saxony. They yield but very poor meat and are bred essentially for their wool. They have become very important in South America, South Africa, Australia, and New Zealand. The animals thrive in dry climates.

(*c*) Cross-bred sheep. These sheep are derived from cross-breeding between merinos and English strains. A large proportion of the Australian and New Zealand flocks are cross-bred. Cross-bred sheep yield both meat and wool.[1]

Shearing by machinery is now usual at most large sheep stations, and as the quality of the wool varies considerably from one part of an animal to another, the fleeces are usually clipped round or "skirted," the inferior clippings being thrown into a separate bin. According to the age of the animal four grades of wool are distinguished:

(*a*) Lamb's wool from 7 months old animals—the finest.

(*b*) Hoggets from 12 to 14 months old sheep.

(*c*) Wether wool from sheep of all other ages.

(*d*) Double fleece, representing two years' growth, is poorer in quality than a single-year fleece from the same animal and is cheaper.

Fleeces vary greatly in weight. Australian sheep average between 5½ and 7 lb.; New Zealand sheep 7½ lb. A prize fleece may be as much as 30 or 40 lb.

Wool is graded according to the "count" or number of 560-yard hanks that weigh 1 lb.

(*a*) Fine counts, from 60 to 90 hanks to 1 lb. These are chiefly merino wools and are short stapled (2½ to 6 inches).

(*b*) Medium counts, from 36's to 60's. These wools are usually

[1] The introduction of refrigerator ships, by increasing the value of the sheep for meat, and thus concentrating attention on that aspect of sheep farming, led to a change in the character of Australian wool.

long stapled (up to 12 inches) and include the wools of English breeds and the cross-bred Colonial wools of South America and Australia.

(*c*) Coarse or low counts, below 36's. These wools are more like hair, and include the wools of Southern Russia, Asia, and North Africa.

Wool as shorn from the sheep contains a large proportion of grease, called "yolk," as well as varying proportions of dirt. It is usually exported "in the grease" and productions are quoted on a "greasy" basis. The wool may be washed to remove dirt, but if the grease is removed the wool felts or mats together.

The wool is washed with water containing ammonia or some solvent to remove the grease—a process known as scouring. Greasy wool loses half its weight when scoured. The grease extracted is known as lanoline and is used in the preparation of toilet soaps. It should be noted that wool taken chemically from pelts is called "slipes."

The carding or combing processes result in the separation of "tops" (the long hairs) and "noils" (the short hairs), which are combed out.

In general it may be said that the woollen branch uses lower and medium grades of wool, "noils," mungo (torn rags and tailor's clippings) and shoddy (wool derived from soft woollen rags and knitwear), whilst the worsted branch uses merino and the finer grades of wool.

In addition, other animal fibres are used for certain purposes. Although including some of the finest of textile materials, the rarer animal fibres are usually handled by dealers specialising in "low wools":

Mohair is obtained from the Angora goat and is an important export from South Africa. There the goats flourish on the Karroo, where it is too dry for sheep. Mohair makes strong, lustrous materials, such as plushes.

Cashmere is the fine, downy winter undercoat of the Kashmir (or Cashmere) goat, a native of Kashmir, Tibet, and Southern China. Each fleece yields only about 3 oz.

Camel's hair is obtained mainly from China and Turkestan. The mane and hump produce strong hair, the remainder of the body downy "wool."

Alpaca, llama, vicuna, and *guanaco* are all animals native to South America, especially on the high Andes of Peru. The wool of the vicuna, a wild animal, is sometimes said to be the finest of all textile materials.

The table on page 474 shows the quantity of wool available for use in the industries in recent years. It should be remembered that the quantity *available* may not be a faithful index of the amount *consumed,* for wool is a non-perishable commodity that can withstand long warehousing.

Owing to the large sheep population of Britain, to the great amount of cross-breeding which has taken place, and to the fact that sheep named after a particular area are rarely confined to

RAW MATERIAL OF THE WOOL-TEXTILE INDUSTRY

(Million lb.)

Variety	Average 1910–14	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Home clip[1]	95	52	72	86	65	56	58
Imported sheep and lamb's wool, mohair, alpaca, etc.[1]	506	467	494	601	597	665	571
Wool from imported sheepskins	35	22	24	27	16	32	37
Mungo and shoddy[2] . .	206	88	84	*	104	55	71
Total quantity of wool, mohair, and pulled wool available in United Kingdom	843	630	675	804	782	808	737

[1] Balance retained, after deducting exports (or re-exports).
[2] Estimated quantity.
* Not available.

that area, it is difficult to generalise about the home clip of wool. Our flocks may be roughly grouped into two classes, however, long-woolled and short-woolled. In the long-woolled class, the best breeds are the Lincoln, which yields a fleece of 9 to 10 lb. in weight, and the Leicester; whilst other breeds are the Cotswold, the Romney Marsh, and the numerous varieties to be found in Devon and Cornwall (*e.g.* the "South Devon" and "Devon Longwool"), in many of the Midland counties, and in parts of Yorkshire (*e.g.* the "Wensleydale"). Most of the long-woolled sheep yield fairly coarse but lustrous wool which is almost invariably combed and spun by the worsted process. The short-woolled sheep fall into two groups, the mountain sheep yielding fleeces weighing about 3 or 4 lb. and the breeds characteristic of the chalk areas yielding 4 or 5 lb. fleeces. The mountain sheep produce very variable fleeces, according to exact breed and region; the roughest wools are used in the carpet and tweed trades, the fine Cheviot wool for woollens, and the soft short wool of the Welsh and Irish mountain sheep is much in demand for flannels. The Southdown sheep produce the finest type of short wool which, until surpassed by Spanish, later Saxon, and now Australian merino, was the chief source of supply for the fine woollen trade. Now much of the Southdown wool is used either for flannels or is combed for hosiery yarn.

Between one-third and one-half of the home clip is exported—a

testimony to its excellent quality—(see table on p. 488) and so extensive imports are necessary to make up the amount required in the wool-textile industries.

GROSS IMPORTS OF WOOL (INCLUDING RE-EXPORTS)

(Million lb.)

Variety	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Sheep and lamb's wool: Merino	801	819	359	364	449	467	416
Sheep and lamb's wool: Crossbred			296	412	332	287	246
Sheep and lamb's wool: Other descriptions			146	73	83	60	41
Wool waste and wool noils	3	4	4	4	6	5	*
Mohair	28	22	14	11	11	7	5
Alpaca, vicuna, llama and camel's hair	13	10	9	8	7	5	7
Wool tops	*	4	3	2	1	1	2
Woollen, worsted, and hair yarn	33	15	18	19	2	7	7
Flocks and shoddy	122	*	51	49	*	*	*
Piece goods (million sq yds.)	65	44	48	62	*	*	*

* Not available.

IMPORTS OF WOOL AND MOHAIR BY COUNTRIES (LESS RE-EXPORTS)

(Million lb)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
New Zealand	143	146	117	119	109	162	142
Australia	126	123	166	218	278	403	320
Union of South Africa	81	60	61	69	65	56	59
Argentina	52	46	53	90	69	4	2
Other countries	104	92	98	105	94	40	48
Total	506	467	494	601	615	665	571

The second of these tables shows that the greater part of the import of raw wool is of Empire origin, Australia, New Zealand, and South Africa being the chief sources. Argentina has almost dropped out of the list. In the remainder the most notable items are Silesian merino, imported on account of its remarkable felting property for the finest woollens; mohair from Turkey and alpaca, etc., from Peru. The first table shows that in addition to raw wool a certain amount of shoddy is imported, and also "semi-finished"

material in the shape of combed tops and spun yarns. The following table indicates the chief ports engaged in importing and exporting wool and woollen goods:

PORTS EXPORTING WOOL AND WOOLLEN MANUFACTURES

(Millions of £'s sterling)

	1913	Average 1927–30	1931	1935	1947	1948
Goole	2·9	4·9	2 7	3·5	3·2	4·7
Grimsby	5·8	3 3	1 4	0·9	0·2	0·2
Hull	5·7	11·5	4 4	8·5	7·2	9·2
Liverpool	11·7	21·1	8·0	10·2	27·0	41·7
London	6·6	10·2	5·2	7·0	8·0	15·3
Manchester	0·7	1 8	0 6	1·1	6 2	10·5
Southampton	1·2	3·0	1 6	2·1	4·2	7·8
Glasgow	0·5	1·6	0 6	0·9	2·0	4·0

PORTS IMPORTING RAW WOOL

(Million lb.)

	1913	Average 1927–30	1931	1935	1947	1948
Goole	6	10	8	9	5	9
Grimsby	15	8	6	4	—	—
Hull	48	136	123	174	83	60
Liverpool	182	143	185	221	229	282
London[1]	485	375	391	346	250	256
Manchester	0·2	14	25	6	20	14
Southampton	61	107	107	97	32	29

[1] The importance of London in this table is a result of the key position held by that city in the world's wool market. The Coleman Street wool sales are as vital to the woollen industry as the transactions of the Liverpool Cotton Exchange are to the cotton industry.

The Chief Branches of the Woollen and Worsted Trades

Only the briefest outline of the processes which lie between the raw wool and the finished cloth can be given here, and technical works should be consulted for further details.[1]

The wool is first sorted and classified into grades—long wools (destined for combing and the worsted trade), short wools (for carding, mainly for the woollen trade), and the lowest class for the carpet trade. In this connection it should be remembered that a single fleece is not homogeneous as regards its quality. Different parts of the animal yield wools of varying length and fineness. An allied preliminary process is the sorting of rags and tailors' clippings and their reduction to shreds in tearing machinery. The

[1] See, for example, A. F. Barker and others: *Textiles and their Manufacture*, Constable, 1922; or J. A. Hunter, *Wool, from Material to Finished Product*, Pitman, 4th ed., 1930.

wool must next be scoured in a soap solution (for which soft water is essential) in order to remove the natural grease which it contains, and machinery must be employed finally to extract all burrs and other foreign bodies which may remain. The dry wool is oiled before passing through the next process in order to render it supple. The short wools are then passed through scribbling and carding machinery, the object of which is to mix up the fibres by taking advantage of their clinging properties and to produce a series of "rovings" or "slivers"—thin ropes of roughly parallel fibres—which are subsequently in the spinning process drawn out and given a twist which makes them into thread. During the carding operation any necessary admixtures (*i.e.* of rag wool, noils or cotton) may be accomplished. The woollen and worsted branches then follow rather different courses. For worsteds, the finer varieties of carded short wool and also the long wools which have not been carded are put through a combing machine which, by more careful means, so as not to cause damage by breakage and crushing, produces slivers of parallel fibres which are subsequently drawn out into finer and finer threads. The noils (short wools rejected during the combing process) go back into the woollen trade.

Then in both woollen and worsted, the finely drawn-out rovings are spun into a continuous thread. For certain purposes, especially to give strength to the yarn and produce a bi- or multi-coloured yarn, "doubling" of the thread is performed (*i.e.* twisting two or more threads into one). All yarns destined to form part of coloured cloths must, of course, have received their dye before being woven. The yarn itself may be dyed, but usually the uncarded wool or the combed tops are dyed before being spun.

Before weaving can commence, the warp and weft threads must be arranged in the required manner. Warping—or building up the warp—is a skilled process, still largely performed by hand; during or after the setting up of the warp, the yarn composing it is treated with size, in order to keep the threads smooth and prevent them from interlocking with one another. The modern high-speed loom is a triumph of automatism, which nothing short of a whole chapter or volume could adequately describe, and the variety of weaves and patterns which can now be mechanically produced is inexhaustible.

The finishing processes are many and varied. The cloth must first be examined for defects and mended where necessary. If woollen, it must be fulled, *i.e.* shrunk and felted—by being passed through rollers and through soap solutions; the nap must be raised by passing the cloth through drums set with teazel heads and then cropped by a kind of mowing machine. For worsteds, in which it is desired to show up rather than conceal the pattern of the weave, raising and cropping are unnecessary, but steaming and pressing

contribute largely to the great variety of finishes which can be produced. If no colour has as yet been given to the wool the cloth may be dyed in the piece before the final finishing processes are completed.

Geographical Distribution of the Wool-Textile Industry

(*a*) *The West Riding*[1].—The dominance of the West Riding in all branches of the wool-textile industry has been a feature of industrial

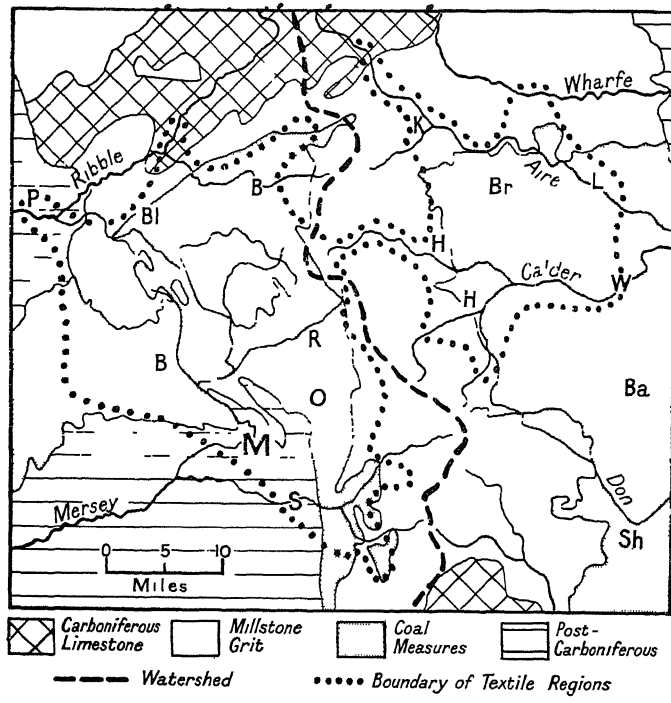

FIG. 217.—The Textile Regions of Lancashire and Yorkshire
Note that the two regions merge across the Roch-Calder watershed

Britain for over a century. Whereas the worsted branch is almost extinct in those areas of East Anglia and the West Country where it once flourished, the woollen section has maintained a somewhat specialised existence in a number of different regions, notably East Lancashire, the Cotswold country and the Tweed Basin. In 1931, no less than 93 per cent. of the worsted workers in Great Britain were in the West Riding, but only 67 per cent. of the woollen operatives. The carpet industry has likewise persisted at several localities

[1] The authors are grateful to Mr. R. S. Taylor for help with the revision of this section, particularly in respect of employment statistics.

EMPLOYMENT IN WOOLLEN AND WORSTED INDUSTRIES, BY REGIONS

	Woollen		Worsted		Woollen and Worsted
	1921	1931	1921	1931	1950
Great Britain . .	139,158	98,525	120,534	103,487	218,700
West Riding (and City of York) .	94,578	65,406	112,376	95,550	168,130
Lancashire . . .	8,457	6,511	320	575	11,070
Somerset, Wiltshire, and Gloucestershire . . .	5,726	4,686	31	26	5,080
Leicestershire . .	486	504	1,132	2,006	1,630
Oxfordshire . .	1,134	1,233	19	15	3,960
Peebles, Roxburgh, and Selkirk . .	9,039	8,275	55	58	20,870

Note: 1950 figures are for Ministry of Labour Regions—E. and W. Ridings, North-western, South-western, North Midlands, Southern and Scotland, and are not strictly comparable with previous Census figures. Included in the total are 7,900 in other regions (mostly in the Northern Region).

EMPLOYMENT IN WOOLLEN AND WORSTED INDUSTRIES, BY PROCESS, 1953[1]

Combing	13,385
Worsted Spinning .	53,471
Worsted Weaving .	32,288
Woollen Spinning . .	22,429
Woollen Weaving .	42,142
Total	163,715

[1] Source: Wool Industry Bureau of Statistics, Monthly Bulletin No. 44. The figures relate to "productive" personnel only, *i.e.* excluding administrative, clerical, and transport staff.

EMPLOYMENT IN CARPET INDUSTRY

	1921	1931	1950
Great Britain . .	23,625	26,936	28,200
Worcestershire . .	6,945	8,902	9,460[1]
West Riding . . .	6,967	5,976	6,480[2]
Glasgow . . .	2,917	3,629	9,270[3]

[1] Midlands region.
[2] East and West Ridings.
[3] Scotland (Ministry of Labour regions).

in Scotland and at Kidderminster, and less than 25 per cent. of the people engaged in the industry in 1931 were in West Yorkshire.

The two features of principal interest within the West Riding are the geographical distribution of the industries and specialities, and the relation between wool textiles and other occupations. Perhaps the outstanding elements in influencing the area covered by the textile-working district, in Yorkshire as in Lancashire, have been the

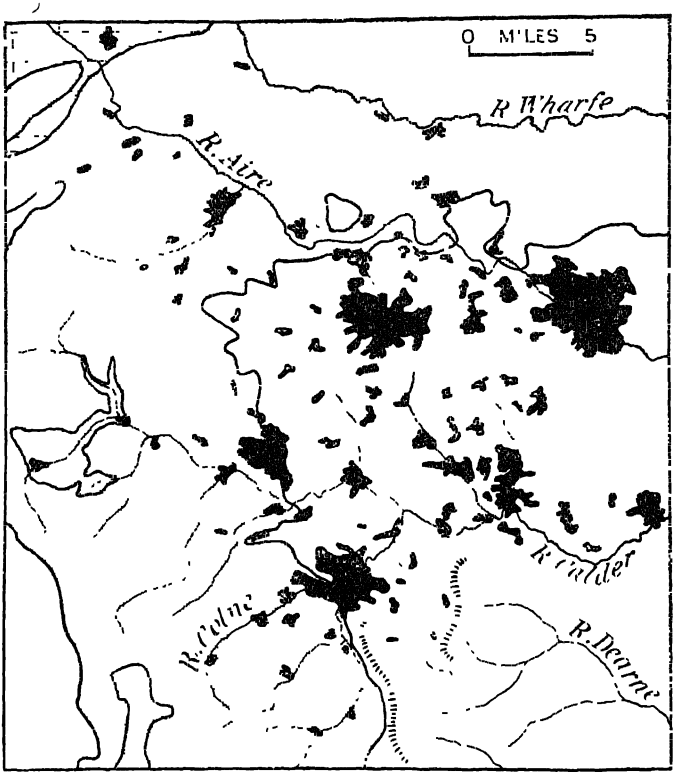

FIG. 218.—The woollen towns of Yorkshire in relation to the streams from the Millstone Grit

The Millstone Grit is stippled, Coal Measures left blank. In the south-west are two areas enclosed by lines which are shown on old geological maps as "Carboniferous Limestone" but are actually of non-calcareous shales now classified with the Millstone Grit. The area in the north-west is of rocks of Carboniferous Limestone age, but is *not* limestone. Notice in the south-east the scarps formed by Sandstones in the Lower and Middle Coal Measures

supply of soft, or lime-free water from the Millstone Grit uplands and the outcrop of productive Coal Measures. The central Pennines, between the South Lancashire and West Yorkshire coalfields, are made up entirely of the Millstone Grit, for the most part peat-covered, and so giving an abundant surface run-off. The Grit consists mainly of hard sandstones, with alternations of coarser and

more porous grits, which act as efficient filters and render the spring water extremely pure.

The West Yorkshire industry is somewhat more localised, however, than the boundaries of the soft-water area would suggest (Fig. 218). Apart from one or two outlying centres on the headwaters of the Dearne and in the Wharfe valley, the industry is confined essentially to the coalfield portions of the Aire and the Colne-Calder valleys, and the area which lies between them, together with the upper portions of those streams on the Grits. Eastwards of Leeds and Wakefield textiles cease to be of any consequence, and coal mining becomes the chief industrial occupation, but westwards of the main region tongues of industry spread up the Colne valley above Huddersfield, up that of the Calder above Halifax to Hebden Bridge and over into Lancashire, and up the Aire to Keighley and Skipton. The northern boundary of the main region is marked by the edge of the coalfield, roughly coincident with the river Aire. It should be noticed that the Aire, unlike the Colne and Calder, rises in a region of Carboniferous Limestone so that its water is not very soft. As a result, no great centres of the textile trade have grown up on it—the chief towns, Keighley, Bingley, Shipley, and Guiseley, being located on small tributary streams rising on the Grits or Coal Measures. The almost sudden cessation of the industry south of the Calder is also remarkable. It is due partly to the paucity of water power in the region of the Dearne headwaters, which rise on the dipslope of the Coal Measure escarpments, but mainly to the long-standing economic differentiation of the Dearne-Don region, where Middle Coal Measure ironstone was formerly smelted and where textile trades (*e.g.* linen and coarse woollen cloths called "pennistones") quite early became subordinate to the coal mining and metal trades of the Sheffield region.[1]

Within this comparatively restricted area there is a good deal of internal differentiation as regards the particular branches or phases of the wool-textile trades which are present. Both woollen and worsted manufactures are to be found all over the area, and there is no sharp regional division between them (Figs. 219, 220). Worsted, however, is of relatively small importance in the south-eastern part of the area—Wakefield and the Dewsbury region—but is dominant in the north-western part—Bradford, Halifax, and Keighley. The region within a radius of about six miles from Dewsbury, comprising the townships of Dewsbury, Batley, Morley, Ossett, Cleckheaton, and Heckmondwike, all north of the Calder, is the greatest in the world for the manufacture of mungo and shoddy and their employment in cloth-making.[2] In Dewsbury and Batley there is a large

[1] But see also E. Charlesworth, "A local example of the factors influencing industrial location," *Geog. Journ.*, XCI, 1938, 340–351.

[2] See S. Jubb, *History of the Shoddy Trade*, London, 1860, for the early development of this industry.

number of firms engaged in the sorting of rags which are subsequently torn up and re-spun and woven into cloth.

Regional specialisation in certain processes—a characteristic feature of the Lancashire cotton industry—is not much in evidence in West Yorkshire, owing to the peculiar organisation of the woollen branch, in which, as we have seen, a large proportion of the firms engage in all or many of the stages between raw wool and finished cloth. Without attempting to over-generalise, it may be said that in the western portion of the region (Halifax and the upper Calder, Bradford and the upper Aire) spinning and weaving are about equal

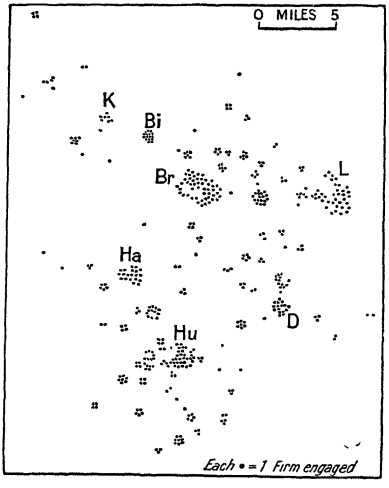

FIG. 219.—The woollen industry of the West Riding

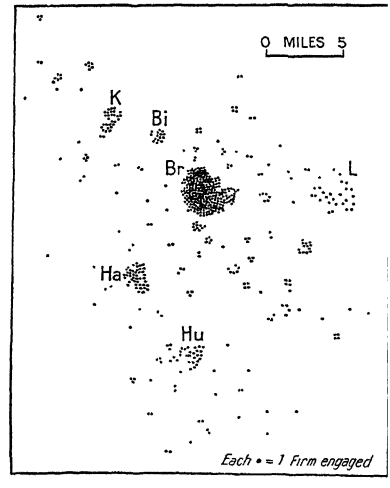

FIG. 220.—The *worsted* industry of the West Riding

Note the general predominance of woollens in the south-east and of worsted in the north-west

K=Keighley Bi=Bingley Br=Bradford L=Leeds
Ha=Halifax Hu=Huddersfield D=Dewsbury

in the numbers they employ in each centre; in the eastern and south-eastern parts, and especially in the small centres south of the Calder, weaving is rather more important than spinning. Dyeing shows a remarkable concentration upon Bradford, attracted thither by the dominance of merchanting and the finishing trades in the city, and is also developed in the middle portion of the Aire valley, between Leeds and Shipley, and in the Calder valley in and around Halifax.[1]

Of individual towns which call for mention, Bradford holds pride of place as the metropolis of worsted and woollen manufacture. This city, apparently in the beginning destined, by reason of its

[1] The textile finishing trades employed over 12,000 people in Yorkshire in 1948, about one-half of whom were concerned with wool and worsted and the remainder with cotton, mixed fabrics, knitwear, etc.

situation on only a tiny stream, to be one of the *less* important centres, has risen since about the 'thirties of last century to a position of prominence unrivalled by its former peers, Leeds and Halifax. In 1800 it had one spinning mill and a population of 13,000. It is probable that the settling within its confines of a number of Jewish merchants, in association with German bankers, soon after 1830, began to increase its importance as a marketing and warehousing

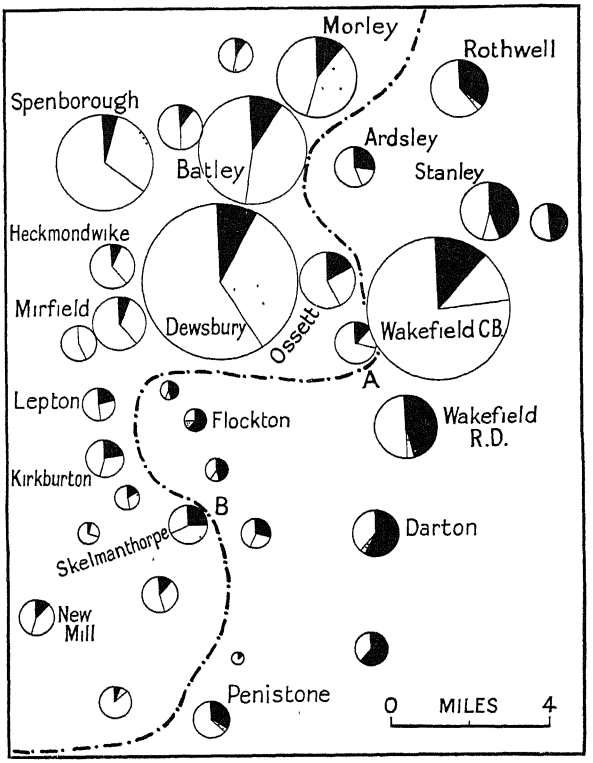

FIG. 221

The transition between textiles and coal-mining occupations by census divisions; circles proportional to the number of people employed in 1921 Black=coal-mining, dotted=textiles; blank=all other occupations. West of the broken line, textiles more important than mining; east of the same, mining more important than textiles. This line of division between A and B coincides with the Calder–Dearne water parting (compare Fig. 218). (Map prepared by H. C. K Henderson)

It is not yet possible to compile this map afresh on the basis of the 1951 Census. But Ministry of Labour employment figures for 1952 indicate that the dividing line has in fact moved slightly into the wool textile area, for Horbury (west of Wakefield), Ossett and Mirfield now have fewer employed in wool textiles than in coal-mining.

centre for worsted goods, and by a process of cumulative growth, and with the aid of the dyeing industry, which was considerably expanded about the same time, it rapidly rose to supremacy. At the present time its activities are concerned principally with combing,

worsted spinning and weaving, and dyeing—but the woollen branch is by no means absent, and Bradford has almost a monopoly in the trades employing alpaca and mohair. Huddersfield concerns itself as much with woollens as with worsteds and is famed for its high-class cloth and its pattern designing. Halifax, until the rise of Bradford, was the chief worsted centre, and it still deals more in worsted than in woollens. It is famed for carpets, although numerically the carpet trade only gives employment to three per cent. of the town's insured workers. Dewsbury, Batley, and the Spen valley towns, as we have seen, form the headquarters of the shoddy trade. Leeds is actually the third town in the conurbation, in respect of absolute numbers employed in the wool textile industry, ranking after Bradford and Huddersfield. But relatively, wool textile manufacture only employs four or five per cent. of the insured workers, and it is the textile-using trades, especially the clothing industry, which are dominant; employment in the latter represents 18 per cent. of the city's total.

As regards the relative importance of wool textiles compared with other industries in the West Riding, some interesting unpublished maps made on the basis of the 1921 Census by Dr. H. C. K. Henderson[1] showed how, eastwards of a zone running southwards from Leeds *via* Ardsley and Ossett to the headstreams of the Dearne, textiles became subsidiary to coal mining (Fig. 221, and cf. map of Yorkshire coalfield, p. 307). Few large mines remain within the textile region, which has thus to a certain extent lost one of the bases upon which its industry was built.

Fig. 222 shows the relative importance of wool textile industries in the various West Yorkshire centres, thirty years later. In every town the wool textile trades are less important relatively, and frequently absolutely also, than they were in the 1920s. This is partly due to increasing mechanisation and the consequent displacement of many employees, and partly to the great increase in the employment capacity of other industries, *e.g.* engineering, electrical trades and numerous "consumer goods" industries, particularly in the larger towns. It is only in a few of the smaller peripheral centres (*e.g.* Slaithwaite, Haworth, Holmfirth) that wool textiles now employ more than 40 per cent. of the insured population.

Of the major urban centres, Leeds is the most diversified city in the whole conurbation, and several occupations exceed wool textiles in importance, such as tailoring (cf. p. 561), engineering (pp. 415, 421), transport services, distributive trades, and professional services. Bradford has a considerable dyeing and finishing industry, together with electrical and general engineering and the making of textile machinery and motor vehicles. Halifax and Huddersfield each make clothing and have textile machinery and other engineering industries, whilst Halifax has also the carpet trade and brass and

[1] Shown to the British Association (Section E) at York, 1932.

wire industries, and Huddersfield a considerable dyestuffs industry and vehicle building. In Wakefield, coal-mining is now three times as important as wool-working (cf. Fig. 221). Dewsbury and the Spen Valley towns have only about one-quarter of their people employed in wool, and there are important textile machinery and other engineering industries. Keighley has textile machinery works (cf. Fig. 209), whilst in the western fringes of the wool-working

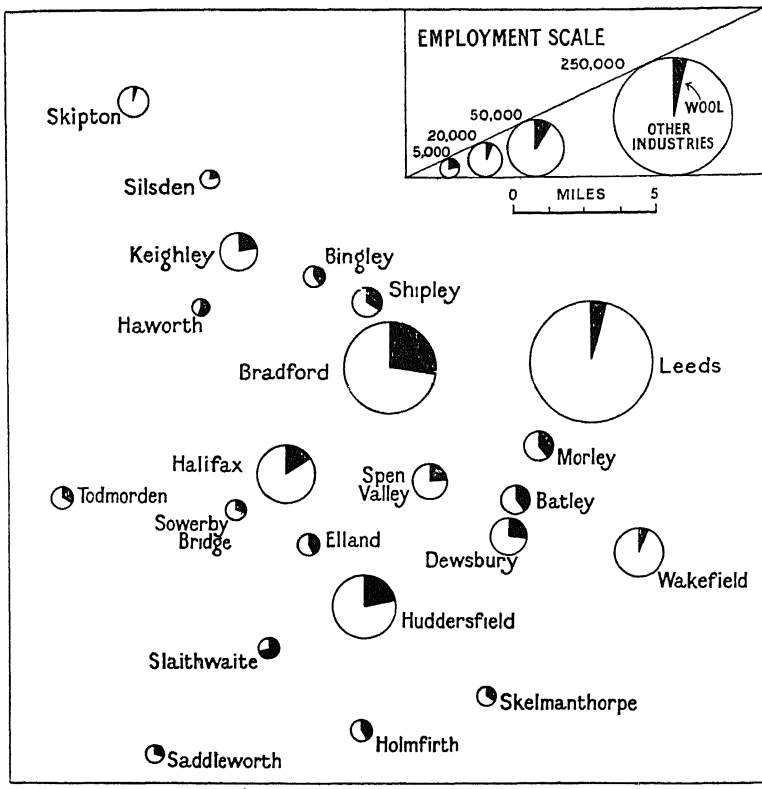

FIG. 222.—Map showing the relative importance of the wool-working industries in the industrial economy of the west Yorkshire towns

district we find Skipton with cotton and rayon trades well developed. Hebden Bridge with large clothing and cotton manufactures, and Sowerby Bridge with a subsidiary cotton industry.

(*b*) *East Lancashire.*—The ancient woollen industry of South Lancashire has become very restricted and specialised since the growth of cotton manufacturing. As stated above (p. 466), it has been pushed eastwards up the Pennine valleys, where there are now two areas concerned, one north of Manchester, in the valley of the

Roch where Rochdale and Bury are the chief centres, and the other east of Manchester, in the Tame valley about Mossley and Stalybridge. The woollen branch predominates, and the specialities are felts (upon which an extensive slipper industry depends), flannels, and blankets.

(*c*) *West of England.*—The decline and increasing specialisation of this region have already been considered (p. 470). The spinning of yarn has practically ceased and the weaving and finishing of special types of cloth is all that remains. Stroud is still the principal centre of the trade in highly finished cloths of the broadcloth type for liveries, uniforms, hunting outfits, and billiard tables. Outlying centres continue to flourish in a small way, such as Dursley, making woollens and carpets, Witney,[1] the blanket town, Trowbridge, woollens and some worsted, Frome, Wellington, and one or two minor survivals of the Devonshire serge trade, as at Ashburton. At Kidderminster the carpet industry continues to flourish after two centuries, and about 9,000 people are employed here and at Stourport.

(*d*) *Wales.*—Many parts of Wales formerly had a considerable domestic woollen industry, using locally produced wool. Much of this industry has been mechanised and factories, most of them small, are to be found scattered in a great many towns and villages in central and west Wales. The greatest concentration is in Carmarthenshire in the valley of the Teifi between Lampeter and Newcastle Emlyn. Flannel is the principal product.

(*e*) *Leicestershire.*—The growth of the woollen and worsted industries is a natural outcome of the expansion of the hosiery trade. As a result, they are of rather a specialised nature, being concerned primarily with the production of worsted and some woollen yarn destined for subsequent manufacture, within the same region, into hosiery proper and all allied types of "knitwear"—underwear, pullovers, bathing costumes, etc. The principal seat of the industry is Leicester, but a number of neighbouring towns share it to a certain extent, as Melton Mowbray, Wigston, and Loughborough (cf. Chapter XXI).

(*f*) *The Scottish Border.*—A well established domestic linen and woollen industry existed in the Tweed basin prior to the Industrial Revolution, based upon local flax-growing and wool from the Cheviot and black-faced mountain sheep, and aided by copious supplies of soft water from the limestone-free Silurian and Old Red Sandstone formations. The decline of the linen trade due to competition from better situated areas in Fifeshire and Ireland, and the introduction of machinery into woollen manufacture, brought about a changed distribution. Attention became focused upon water-

[1] One firm at Witney claims to have been making blankets since 1670. See A. Plummer, *The Witney Blanket Industry*, Routledge, 1934.

power sites on the change of gradient between the narrow tributary valleys and the broader central basin of the Tweed—and towns situated in such places as, for example, Galashiels and Hawick, expanded considerably as a result. Subsequent development was hampered, however, by the absence of coal, the somewhat isolated nature of the region as regards populous markets, and the attendant lack of facilities for easy import of foreign wool. Competition with Yorkshire being out of the question, specialisation has occurred and the region has become world-famous for "tweeds"[1] of high quality, and for hosiery of all kinds, the latter being the speciality of Hawick. In consequence much foreign wool is now imported, and the industry survives to-day by reason of a foundation laid during a period when local geographical conditions were more favourable. The site conditions, owing to the narrowness of the valleys, are not very favourable for mill and town development, and in the 'seventies of last century the Galashiels industry had to find a new outlet at Selkirk, with the result that the population of the county named after that town increased by 80 per cent. between 1871 and 1881.

The depression which followed the First World War, with its accompanying lack of real demand for the costly high-quality products, hit the industry badly. A partial relief was obtained by the introduction, as at Jedburgh, of the artificial silk trade; but the present adverse geographical and economic factors are outweighing even the momentum of several centuries.

(*g*) *The Rest of Scotland.*—Just as in Wales, the natural aptitude of many parts of Scotland for sheep rearing, together with the abundance of soft water, gave rise to a widespread domestic woollen industry, of which, despite the progress of mechanisation and the development of factories, many scattered remnants still remain. Small mills for spinning and weaving tweed and other cloths, blankets, and carpets are to be found in nearly every county, and only one or two of the more important regions can here be mentioned.[2] Although completely overshadowed by more modern industries, the old woollen trade survives in Ayrshire, as at Kilmarnock and Ayr, and in the Glasgow–Paisley district, where carpets and blankets are made and where the industry is partly an associate of the cotton industry. Between the Forth and the Tay, on the steep southern slope of the Ochil Hills, where there was abundant water power, the woollen industry still remains centred on Alva, Alloa, and Tillicoultry; and numerous small mills are to be found in the valleys running south-eastwards and north-eastwards from the

[1] The name was originally "twill" or "tweel," which an English clerk's error transformed into tweed—and this misspelling happening to be the name of the river basin, it has stuck to the cloth and the trade.

[2] In 1948 (Census of Production) the wool and worsted trades in the whole of Scotland gave employment to just over 17,000 people, and carpet-making to a further 7,000.

EXPORTS OF WOOL AND WOOLLEN GOODS BY VARIETY
(In 100 Centals = 10,000 lb.)

Variety	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Wool (British only)	2,866	5,209	4,118	3,577	*	1,745	2,536
Noils and waste	3,388	3,449	3,166	2,011	3,580	3,708	4,938
Tops	4,363	3,736	3,431	2,799	5,593	6,009	7,289
Yarn, worsted	4,990	3,712	3,786	2,978	3,308	2,076	2,396
Yarn, woollen	481	784	654	515	781	468	605
Tissues, worsted (million sq. yds.)	62	54	41	30	38	38	40
Tissues, woollen (million sq. yds.)	106	129	113	56	71	73	84
Yarn, alpaca, and mohair	1,722	738	761	406	438	172	220
Other yarns of hair and wool	848	307	712	640	*	183	300
Flocks, shoddy, and rags	2,326	2,501	3,106	2,269	*	2,853	4,350
Piece goods (million sq. yds)	187	185	169	95	*	*	*
Carpets (million sq. yds.)	11	7	7	3	6	10	12
Blankets (1,000 pairs)	1,002	1,235	990	409	417	1,379	1,360
Flannels (million sq. yds.)	—	6	4	3	5	5	*

* Not available.

EXPORTS OF WOOL AND WOOLLEN GOODS BY COUNTRIES
(Millions of £'s)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Germany	9·5	7·0	8 7	4 0	2 4	3·6	10·4
Canada	4·4	6·2	6 6	2 6	3 4	16 0	19·6
Australia	2·4	5·3	3·1	0·3	1 1	10·3	12·2
New Zealand	0·5	1·2	1·3	0·6	0·8	5·2	7·9
South Africa	1 5	1·5	1·6	1·2	1·9	7·3	6·8
China	0·6	3 7	3 2	1 8	0·6	0 3	0 4
Japan	1·9	7·3	2 8	1 2	0·7	0·5	1·3
India	1·3	1·0	1·3	0·4	0·7	4·0[1]	5·0[1]
Other Countries	11·9	27·4	22·4	13·1	18·8	69·9	105·6
Total	34·0	60·6	51·0	25·2	30 4	117 1	168 2

[1] India and Pakistan in 1949 and 1950.

Grampian massif. Finally, mention must be made of the hand-loom production, in the Hebrides, of the famous "Harris homespun" tweeds; and of the domestic hosiery industry of the Shetlands. These trades are now much more commercialised than formerly, and machine-spun yarn is used in order to speed up production.[1] The chief spinning centre in the Highlands is Brora, on the small coalfield.

(h) Ireland.—Here, as before, we find a scattered domestic woollen industry which has become partly industrialised. A number of small towns in Northern Ireland, and some in Eire, notably in the hinterland of Cork, have mills where woollen cloths, tweeds and blankets are produced, but Ballymena, Belfast, and Cork are the only towns where more than one firm is engaged.

[1] The term "Harris Tweed" is restricted to cloth produced from Scottish wool spun in the Island and woven in the houses of the people. There are several carding and spinning mills, mostly at Stornoway, but there are some 800 members of the Harris Tweed Association; they produce 3 to 4 million yards of cloth a year, all of it of high quality and much of it destined for export. The industry is the mainstay of the economic life of many of the Islanders.

WOOLLEN AND WORSTED INDUSTRIES: PRODUCTION

(Million lb.)

Variety of Product	1907 (United Kingdom)	1924 (Great Britain)	1930 (Great Britain)	1950 (United Kingdom)
Tops	243	286	244	316
Noils	30	35	28	*
Yarns	446	550	373	656
Woollen	260	314	191	329
Worsted	—	211	158	227
Alpaca and mohair	186	15	8	—
Other hair or wool	—	10	15	*

(Million yards)

Variety of Product	Linear	Square	Square	
Wool and worsted tissues	246	419	304	*
Damasks, plushes, etc.	7	10	5	*
Flannels and delaines	51	25	16	*
Blankets (thousands of pairs)	3,103	3,017	3,074	3,500

Note.—Ireland produces a small amount of wool and worsted yarns only.
* Not available.

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CHAPTER XX

THE TEXTILE INDUSTRIES: COTTON [1]

THE cotton industry, unlike that of wool, has no long history stretching back into the Middle Ages: its expansion is roughly coincident with the period of the Industrial Revolution. Moreover, it has always been entirely dependent upon imported raw material, and it is to-day very largely dependent upon foreign outlets for its produce. The study of its development and localisation is thus intimately bound up with considerations of sources of power and of inland and ocean transport facilities. But this is not all. Of the 440,000 people employed in the industry in 1931, no less than 84 per cent. were enumerated in Lancashire and the adjacent parts of Cheshire and Derbyshire.[2] Such a remarkable concentration cannot be due to power supplies and port facilities alone, for several other regions of Britain possess equally good advantages in this respect. It will, therefore, be our business in this chapter to attempt an analysis (*a*) of the factors which contributed to the original localisation of the cotton industry in Lancashire and elsewhere, and (*b*) of the physical and economic circumstances which have enabled the Lancashire region to adapt itself to new discoveries and new requirements, and so to develop the remarkable concentration and specialisation which characterise it at the present time.

Historical Geography of the Cotton Industry[3]

(*a*) 1600–1770.—It is probable that, from the thirteenth century onwards, small quantities of cotton wool were imported into England for the making of candle wicks, and in the sixteenth century this trade was fairly regular. Definite evidence of the spinning and weaving of cotton in this country is lacking, however, until

[1] By S. H. Beaver. The authors were greatly indebted to Mr. J. A. Todd, Principal of the Liverpool School of Commerce, for his valued criticism of this chapter in the original form. Mr. H. L. Beales kindly read through the historical sections.

[2] At the Census of Production, 1948, of 258,710 employees in cotton spinning, doubling, and weaving, 221,064 (85 per cent.) were in the North-Western Region (Lancashire, Cheshire, and N.W. Derbyshire).

[3] Of the abundant literature on the history of the cotton industry, the following books are "classics": E. Baines, *History of the Cotton Manufacture*, 1835; S. J. Chapman, *The Lancashire Cotton Industry*, 1904; G. W. Daniels, *The Early English Cotton Industry*, 1920; Wadsworth and Mann, *The Cotton Trade and Industrial Lancashire, 1600–1780*, 1931. A more popular account will be found in Wood and Wilmore, *The Romance of the Cotton Industry in England*, 1927.

about 1600. Cotton had been utilised on the Continent for a considerable period (in Spain, Italy, Germany, and Belgium, for example) and it is probable that Flemish refugees introduced it into Britain. At Norwich, the home of fine fabrics (cf. p. 465), fustians and bombazines (mixtures of linen and cotton, or silk and cotton) were being made, possibly before 1600 and certainly in 1605, and in South Lancashire, where many foreigners settled, fustians began to be produced about the same time, using cotton imported from Smyrna, the Levant, and Cyprus, and linen from Scotland and Ireland. In East Anglia the manufacture was clearly an ally of the worsted industry which we have already discussed (Chapter XIX). In South Lancashire it attached itself quite naturally to an existing linen and woollen industry. Manchester was making woollen cloth in the early fourteenth century, and in the sixteenth century the linen trade of Manchester, and the "Manchester cottons" (made of wool) produced at that town and at Bolton are commented upon by Leland. The use of cotton was slow in developing, however, and as yet the fibre was only used for mixing with others, for it could not be spun into a thread strong enough for employment as warp. By the end of the seventeenth century, aided by the great damage done to the Continental industry by the Thirty Years War, and by the increasing demand for fustians, the industry was definitely established and concentrated chiefly in the Manchester region.

Manchester, like Birmingham (cf. Chapter XVIII, p. 437), was a non-corporate town—"neither walled town, city, or corporation" (Defoe)—free from the strict regulations of the larger populous centres and thus able to accommodate foreigners and new industries without trouble. It lay, too, outside the area dominated by the trading activities of the Merchant Adventurers, and so could develop unhampered by restrictions. Three branches of the textile industry grew up—the woollen "cottons" referred to above, checks and small-ware (tapes, etc., often made of worsted), and fustians (made from linen warp and cotton weft). At the same time, whilst Manchester was the centre of the new industries, Bolton also made fustians, Rochdale and East Lancashire generally still retained a flourishing woollen trade, and Warrington, developing as a port, was famed for its sail cloths. The prohibition (at the instigation of the silk and woollen manufacturers) of the import of printed and dyed calicoes (obtained from India), in 1700, resulted in the setting up of a printing and dyeing industry in London (where the "grey" cloths were imported) and in Lancashire; and when in 1721 the *use* of printed calicoes was forbidden, Lancashire took up fustian-printing, an industry which was legalised by the famous "Manchester Act" of 1736.

The steady, if slow, expansion of the cotton-using industries

in Lancashire during the first half of the eighteenth century[1] was accompanied by the rise of Liverpool as a port. With the gradual silting up of the Dee estuary, Chester was declining,[2] and the improvement of Warrington in the 1690's, followed by the construction of the first docks at Liverpool in 1715, and the improvement of the Mersey–Irwell navigation to Manchester, commenced in 1720, are evidence of the need for oceanic inlets and outlets for the growing trade of South Lancashire. Liverpool was not really important as an importer of raw cotton, however, until the main source of supply shifted from the East to the West (*i.e.* the United States). The one great handicap of the Manchester region (cf. Birmingham) was the lack of good roads. The pack-horse provided the only available means of overland transport and most of the raw

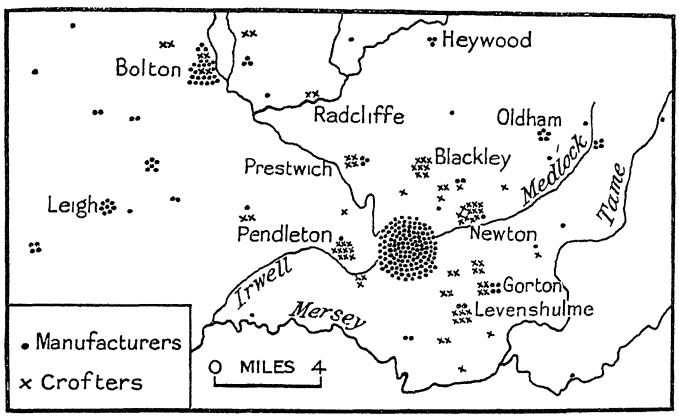

FIG. 223.—The distribution of cotton users in South Lancashire at the end of the pre-machinery period

cotton was obtained from London by this method. Another feature which prevented much expansion until after the invention of machinery was the scattered and rather widespread nature of the domestic spinning and weaving industries, which at this time were largely part-time occupations of families also engaged in farming. Although from quite early times the merchants (the equivalent of the Yorkshire "clothiers") employed large numbers of people, large-scale output of homogeneous fabrics was obviously impossible before the coming of the factory age.

Fig. 223 shows the distribution of the cotton-using industries in South Lancashire at the end of the pre-machinery period.[3] The

[1] In 1701, just under 2,000,000 lb. of raw cotton were imported; in 1751, nearly 3,000,000 lb.

[2] See H. W. Ogden, "Geographical Basis of the Lancashire Cotton Industry," *Journ. Textile Inst.*, XVIII, Nov., 1927, pp. T573–594 (useful maps).

[3] Data from Daniels, *op. cit.*, pp. 69–70.

concentration on the Manchester district is remarkable, and may be regarded as an expression of the dominance of that town over the Lancashire region. Defoe had described it as "the greatest mere village in England," with a population, in its parish, of some 50,000; and whilst there was as yet no incentive to move into the comparatively barren hill country in search of water power, the lowland agricultural area around the Medlock and middle Irwell basins proved the more attractive region. Of the "manufacturers" shown in Fig. 223, the makers of small-ware were all in Manchester; the check-weavers mostly in Manchester and an "inner circle," comprising what are now the city's suburbs (e.g. Failsworth, Gorton, Levenshulme) and the fustian makers in Manchester, and in an outer circle (*e.g.* Leigh, Bolton, Oldham). The crofters or "whitsters" who performed the bleaching operations[1] were grouped in the villages around Manchester (Blackley, Newton, Pendleton) and in the Irwell valley (*e.g.* Prestwich, Radcliffe, Bolton)—a location which, as we shall see, has been preserved even to the present time, though the methods and requirements have changed considerably.

(*b*) *The Industrial Revolution.*—The factors which contributed to the localisation of the cotton industry in South Lancashire in the seventeenth century—the existence of linen and woollen industries in the soft-water region of the Pennine flanks, and the settling of foreigners in a non-corporate town are not sufficiently exclusive or conclusive to explain the present concentration. Numerous other regions had soft water, Flemish weavers, and an atmosphere humid enough for successful spinning. The secret of the expansion of the industry in Lancashire lies in the fact that as each new development arose, so the natural environment of the region was found capable of being utilised in the desired manner. When machinery was invented, water power was available; when steam power arrived coal could not have been in closer proximity; the development of chemical bleaching was aided by the presence of the Cheshire salt field, only a few miles away, and by the abundance of soft water; and the need for transport could be satisfied by comparatively easy canal and railway construction, and by the enlargement of the existing ports of Liverpool and Manchester. The Industrial Revolution period witnessed all these factors in operation.

Prior to the invention of machinery the textile industries were essentially home occupations. The home-made spinning wheel and hand loom were the only essential requirements. The difficulty which weavers experienced in getting adequate supplies of

[1] The method employed was to steep the cloth in sour milk, spread it out on grassy slopes, and allow the sunlight to do the bleaching. It was a process occupying several months.

yarn[1] was only aggravated by Kay's flying shuttle (patented in 1733, but not much used until the 60's), and in consequence the early inventions were all designed to facilitate the spinning process. Hargreaves' "jenny" (named after his daughter) merely multiplied the number of spindles which could be handled by one operative,[2] and still could not produce a yarn strong enough for warp. Arkwright's invention[3] of roller spinning, however, making use of rollers moving at different speeds for drawing out the rovings into yarn, remedied this deficiency. His machine, although patented at first to be worked by a horse, was quickly adapted for driving by water power, and hence came to be known as the "water frame." It may be said to have wrought two great changes in the cotton industry. In the first place, it made possible the weaving of all-cotton cloth (calico)—a manufacture which, owing to the existing prohibitions (*vide supra*), had to be legalised in 1774—and thus, by rendering unnecessary the admixture of linen and wool, contributed to the decline of those industries in Lancashire;[4] secondly, it caused the first vital change in the localisation, within Lancashire, of the production of yarn, by making water power an essential. But progress in the use of water power was at first slow. There was a natural reluctance on the part of the people to work in factories; then the lapse of Hargreaves' patent allowed the rapid spread of the jenny, which needed no power, and Arkwright, driven from Lancashire by hostility to his machines,[5] set up his works in Nottingham, the home of flourishing hosiery, lace and silk industries, and later at certain water-power sites in the hosiery-making district of Derbyshire (Cromford 1771, Derby 1773, Belper 1776). Another factor contributing to the expansion of the industry was Crompton's mule, constructed in 1779 and so called because it combined the principles of the jenny and the roller. This machine spun thread for both warp and weft, and was capable of producing counts of much greater fineness than ever heretofore. As it was never patented, its use quickly spread, and in the 80's it began to

[1] "It was no uncommon thing for a weaver to walk three or four miles in the morning and call on five or six spinners before he could collect enough weft to serve him for the remainder of the day." (Guest, *Compendious History of the Cotton Manufacture*, p. 12.) The situation was aggravated in the summer months by the spinners neglecting their spindles for more urgent agricultural labour.

[2] The first jenny, in 1770, had 16 spindles. Twenty years later machines were being constructed with over 100.

[3] Like so many "inventions," the principle of roller spinning was not the product of the brain of the man whose name is associated with it. It is due to Lewis Paul, whose first machine was made in 1738—thirty years before Arkwright's patent.

[4] By 1790 woollen manufacture had disappeared, except in a specialised form in East Lancashire, and the linen industry was almost dead.

[5] Arkwright did not at first intend to make calico, but as the Lancashire weavers refused to buy his machine-made yarn he had to use it himself in the manufacture of all-cotton cloth

supersede the jenny. It was not adapted for water power until 1790, after which, during the last decade of the century, it was adopted for producing the finer types of yarn, Arkwright's water frame spinning the coarser counts.

The early machinery age thus falls naturally into two periods. The first, from 1770–90, is characterised by the endeavour to provide an adequate supply of yarn, by the birth of the new cotton industry, by the inauguration of the factory system, consequent upon the use of water-driven machinery, and by an important migration of the industry away from Manchester and into the steeply graded valleys of the western Pennines and the Rossendale upland, where water power was available. The second, from 1790 until 1800, is a period of development and consolidation, in which two pieces of machinery played important parts. The mule enabled the trade in fine fabrics, for so long an Indian monopoly, to be captured by Lancashire and by the Glasgow–Paisley district of Scotland, where the cotton industry began to supersede that of linen (see p. 506). The steam engine, which Watt began to develop for driving machinery about 1782,[1] not only enabled far greater power to be obtained, but also confirmed the existing localisation of the industry on the Lancashire and Lanarkshire coalfields. The increasing use of machinery gave rise to a new industry—the building of machines for the mills which were springing up in many of the coalfield valleys. The import of cotton rose by leaps and bounds, a new and prolific source of supply appearing in the United States.[2]

All this time, however, weaving had lagged seriously behind spinning in technical developments, with the result that the hand-loom weavers, supplied now with a surfeit of machine-spun yarn, were enjoying a period of great prosperity. It is true that Cartwright had invented a power loom in 1785, but although several were erected none was successful until, about 1804, Radcliffe overcame the liability of the cotton yarn to break when subjected to mechanical handling by steeping the warp in boiling size before mounting it in the loom. Thus it was not until about 1806 that the power loom, later improved by Horrocks, became a commercial proposition—to the serious detriment of the hand-loom weavers.

Two trends are to be discerned in the localisation of the weaving industry. At first, there was a temporary migration of many of the cottage looms into weaving sheds attached to the new beck-side spinning mills. Then, with the introduction of the power loom, a process of disruption began, due to a number of causes. The hand-loom weavers were a body of skilled workers who objected

[1] The first engine for a cotton mill was erected at Papplewick, Notts, in 1785; Manchester obtained its first in 1789, and Glasgow in 1792. By 1800 Manchester had thirty-two steam engines.

[2] Import of raw cotton in 1781—5,000,000 lb.; 1800—56,000 000 lb. See also p. 508.

to working in "factories," and who saw in the coming of machinery the grim spectre of unemployment and ruin. Unlike the early spinning machines, the power looms did not need skilled operatives and could be worked or attended by women and children—at, of course, low wage rates. It is little wonder then that many of the early machines and factories were damaged or destroyed in a series of riots during the second and third decades of the nineteenth century.[1] Many weaving masters, potential factory builders, migrated to the northern slopes of the Rossendale upland, where the cotton industry was less highly developed and where the hatred of machinery was less intense. To this migration, and to the increasing separation of spinning and weaving, due to the large number of new fabrics and the impossibility of weaving firms spinning all the varieties of yarn which they required, the beginnings of the modern specialisation in the industry, dating from about 1840, are due.[2] The use of the power loom did not take the industry by storm, however, as the spinning machines had done,[3] and for a long period, just as in the woollen industries, the hand loom continued to be an important factor in cotton manufacture. Even in the 1830's, when the cotton industry in Great Britain possessed about 100,000 power looms, perhaps 250,000 hand-loom weavers remained.[4] Some remained—in Glasgow for example—even after 1880.

It must not be assumed that spinning and weaving were the only two processes in the cotton industry to be mechanically performed. As far back as 1748 Lewis Paul had patented a carding engine, and Arkwright placed a whole series of carding and drawing machines on the market in the late 70's. Many other machines were designed to perform the many processes through which the raw cotton goes before it is ready for spinning.

Another very important series of inventions concerned the bleaching and dyeing of yarn and cloth and the printing of calico. The year 1785 witnessed great advances in the methods of both bleaching and printing. Berthollet, a French chemist, discovered the bleaching properties of chlorine and his ideas quickly became known in Lancashire, the centre of the English calico industry. The new process, as improved by Henry and others in Lancashire, reduced the time necessary from many months to a few days. Its

[1] We must not assume that the Luddite and other riots were due *entirely* to the fear of machinery. The general resentment of wage levels and food prices during the great post-war depression should also be taken into consideration. (Daniels, *op. cit.*, pp. 83–91.)

[2] See J. Jewkes, "The Localisation of the Cotton Industry," *Economic History*, II, Jan. 1930, pp. 91–106.

[3] Domestic spinning was almost extinct in the towns by 1785, although it lingered in the country districts for several decades. In 1813 there were about 100 power looms in the Manchester district, and about 2,400 hand looms.

[4] This figure, given by Baines (*op. cit.*, p. 396), is generally regarded as being too high.

essential requirements were chlorine, easily obtained by canal from the salt deposits of Cheshire; lime, sent by canal from the Carboniferous Limestone region of Derbyshire,[1] and sulphur, which began to be obtained from pyrites imported from Spain *via* Liverpool. The assembly of these raw materials by canal and sea resulted naturally in the foundation of a chemical industry at the head of the Mersey estuary, whilst the bleaching industry suffered no change in its location. The bleaching works of the pre-machinery period were fortunately (for boiling water of lime-free character is the chief item in the process) situated on the coalfield and well within the soft-water area of the southern flank of the Rossendale upland, and were also near to Manchester, the finishing and marketing centre.

In 1785 also, cylinder printing was invented. Replacing the old wood-block and copper-plate methods, which had been in use in Lancashire for twenty years, this piece of machinery, later assisted by the transfer process of engraving, could perform the work of 100 men, and so greatly speeded up the printing of calico, reduced costs and enabled a vastly greater output to be obtained.

The development of the cotton industry was facilitated during the Industrial Revolution period by the growth of transport facilities, especially in the form of canals (cf. Chapter XXVI). Although the earliest canals (Sankey Canal, 1760; Bridgewater Canal, 1761) were designed to provide outlets for the coalfield, the rapid development of the cotton industry after 1770 was followed by a period of intensive canal construction. The Leeds and Liverpool Canal provided an outlet for the northern area (Blackburn–Burnley) as well as for the wool textile region of the West Riding; the Rochdale Canal served Rochdale and the south-west of the Yorkshire woollen region; the Manchester, Bolton and Bury Canal served the Irwell valley; and the Huddersfield Canal linked the Ashton–Stalybridge area with Manchester. Many new mills grew up alongside these canals.

The essential features of the modern Lancashire cotton industry were thus outlined during the Industrial Revolution period, and just as in the wool textile industry the localisation has changed little since that time, although the relative importance of the various centres may have been somewhat modified. Thus in 1838 Manchester still had more people employed in the cotton industry than any other town, and the towns north of Rossendale had scarcely become important at all.[2]

[1] The Peak Forest Canal, connected by tramway from its terminus at Bugsworth with the limestone quarries of the Doveholes area. Cf. Fig. 231, on p. 542.

[2] Cotton operatives in 1838 (Factory Inspectors' Returns, quoted by Chapman *op. cit.*, p. 151)—towns having 10,000 or more ('000 omitted): Manchester 39·4, Stockport 23·8, Oldham 15·0, Bury 13·7, Ashton-under-Lyne 12·1, Rochdale 10·9, Blackburn 10·5, Bolton 9·9. Note the absence of Burnley, Accrington, Nelson, and Colne from the list—actually no figures are given at all for these towns in 1838.

(*c*) *Modern Growth and Specialisation.*—The main trends to be observed in the industry since the Industrial Revolution are six in number. (1) An absolute expansion of the output, accompanied, however, by a decline relative to the world's total (cf. iron and steel, and shipbuilding). The only serious set-backs received until the First World War were the result (*a*) of the cotton famine brought about by the American Civil War; (*b*) of the great depression of 1873–1896, during which the general economic depression, the depreciation of silver (affecting the purchasing power of Eastern countries), and the commencement of foreign competition combined to arrest the triumphant progress of the first half of the century. (2) An increased separation of the spinning and weaving branches, with the development of a "horizontal" system of organisation. (3) An increased specialisation in the finer types of yarn and fabric, and in fabrics for special markets—a consequence of foreign competition in the production of cheap goods and of the comparatively high cost of raw material as a result of distance from its source. (4) Changes in the mode of transport, the railway superseding the canal, and the road now seriously competing with the railway for the carrying of raw cotton and manufactures. (5) The growth of associated industries, notably textile-engineering and the manufacture of chemicals. (6) The beginning, in recent years, of a change in the source of power, increasing use being made of electricity.[1] There is one feature which distinguishes the cotton from the woollen industry during the Industrial Revolution period, however, and that is the earlier mechanisation of cotton manufacture. Cotton was a well-established factory industry in the 30's when the greater part of the wool textile industry, with the exception of worsted spinning, was still in the domestic stage.[2]

[1] Power employed in cotton industry 1924 and 1930 (Census of Production). (Cf. footnote on p. 471, Chapter XIX.)

	1924	1930
Prime movers (steam engines and turbines)	328,000 h.p.	283,000 h.p.
Electric generators driven by prime movers	20,000 kW.	28,000 kW.
Electric motors and purchased current . .	52,000 h.p.	75,000 h.p.

At the Census of Production, 1948, the cotton spinning and weaving industries were recorded as having spent £4·9 mn. on coal and £1·8 mn. on electric current.

[2] Persons employed in textile factories (*British Commerce and Industry*, Ed. by J. W. Page, vol. II, p. 230).

	Cotton	Wool
1835 . . .	219,286	55,461
1850	330,924	154,180
1861	451,569	173,046
1870 .	450,087	238,503
1880	528,795	301,556

Before considering these trends in detail we must pause and examine the geographical background of the cotton industry in Lancashire and in Scotland.

The Geographical Background of the Cotton Industry

(*a*) *Lancashire.*—In analysing the factors which have contributed to the remarkable concentration of the cotton industry in Lancashire we must attempt to differentiate between true localising factors, *i.e.* factors which were responsible for the placing of the industry just where it is, and factors which have merely been assets in confirming that localisation and in hindering any serious migrations into other regions. In the first category we have the historico-geographical influences already dealt with—the physical environment which aided the rise of woollen and linen industries on the western flanks of the Pennines (cf. Chapter XIX), and the part played by Manchester, as a non-corporate town, in attracting industry to itself. In the first class, too, are the water power provided by the numerous steeply graded streams and the soft, lime-free character of the water of those same streams. The combination of lime-free water and water power has been the most powerful factor in determining the location of the individual producing centres and the boundaries of the cotton-working region. Of the second class, first and foremost is the existence of productive coal measures. Lancashire could scarcely have attained to its present position had it not been for the coalfield; the industry would probably have died a natural death before the middle of last century. Other important auxiliary factors are the naturally high humidity of South Lancashire, which reduced the necessity for expenditure upon humidifying apparatus for spinning mills; the proximity of the Cheshire saltfield, providing essential materials for the bleaching industry; and the facilities for rail, water and road communication offered by the natural routeways of the Pennine and Rossendale streams, and by the flat plain of south-west Lancashire between Manchester and Liverpool.

The physical setting of the industry has already been alluded to; let us now examine it in rather more detail. The core of South Lancashire is the Rossendale anticline, trending in a WSW direction from the monoclinal axis of the Pennines. On the north side of the upland are the towns situated in the valleys of the Darwen and Calder, tributaries of the Ribble; south of the upland are the towns in the middle Irwell and Roch valleys; and in the denuded heart of the upfold lie the towns strung along Rossendale, the upper valley of the Irwell. The fourth group of cotton-working centres lies in the valleys of the Medlock, Tame, and upper Mersey, which flow down from the Pennines (Fig. 224). The Pennine region and part of the Rossendale upland are made up of the thick Mill-

stone Grit Series, and the flanks of the latter are composed mainly of Lower Coal Measures. These systems are characterised by similar lithology, consisting mainly of hard sandstones (hence forming uplands) with alternations of shales and porous grit beds (and in the latter formation some coals). They therefore give rise to an abundance of lime-free surface water and although, owing

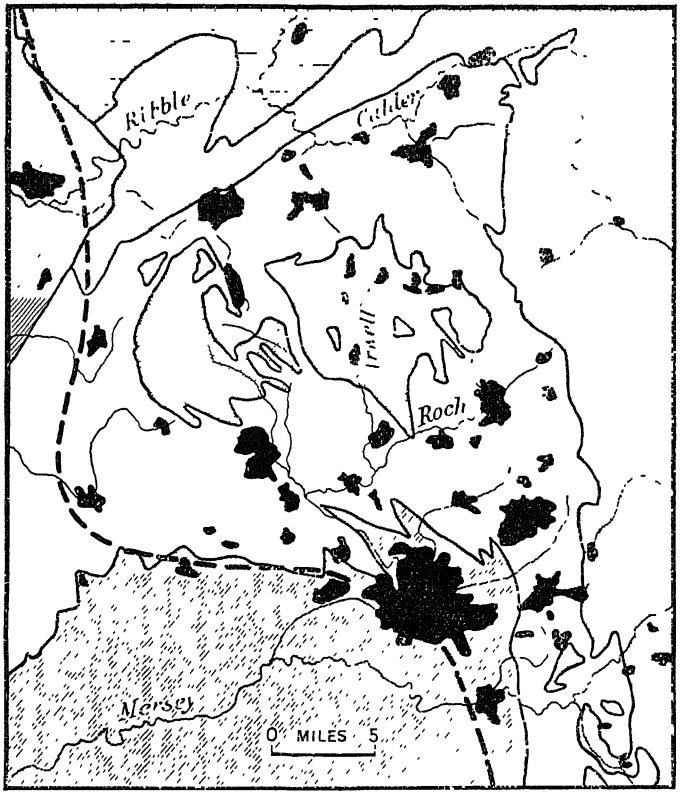

FIG. 224.—The cotton-working towns of Lancashire, showing the relation of their position to geological outcrops and soft-water supplies

Carboniferous Limestone outcrop shown on the north, Millstone Grit, dotted. Coal Measures, blank; Trias, lined The heavy broken line marks the westward limit, according to H W. Ogden, of soft water (hardness under 10)

to their low porosity, they are not good water *bearing* formations, the deep narrow valleys which dissect the uplands can easily be dammed in order to ensure copious and constant supplies. The regularity of the stream régime is a result of the comparative evenness of the precipitation through the year (partly, no doubt, due to orographical influence on the rainfall in a west-facing upland

area) and of the thick accumulations of spongy, water-holding peat which cover the moors.

The extent to which the need for soft water, at first for washing and cleaning, bleaching and dyeing, and later to an even greater extent for the chemical bleaching process and for the steam-producing boilers, has limited the outward expansion of the industry, is seen in Fig. 224. Water having a permanent hardness of more than 10 degrees (*i.e.* 10 grains of carbonate of lime, or its equivalent in other lime or magnesium salts, per gallon of water) is very difficult to lather, and this makes for much wastage of soap and chemicals; moreover, the excess of lime is deposited as scale in the boilers and pipes of the power-producing plant. Although water-softening apparatus is now available, the cost of installation and upkeep is not likely to assist in the construction of new mills outside the soft-water area. We thus find that the cotton industry did not develop on the Triassic, drift-covered area of south-west Lancashire, nor on the flanks of the limestone Pennines; the absence of water power in the former region provided a further check to the westward expansion of the industry. The northern boundary of the cotton-working region is probably the result of the interaction of several factors. The more diversified lithology of the rocks underlying the Ribble basin, together with the fact that the Ribble itself rises in one of the most extensive areas of limestone in northern England, render the softness of the water less reliable (since hard, spring water from limestone tends to flow more constantly than soft, upland drainage water, which tends to concentrate into floods, and thus the hardness of the stream water varies according to season). Moreover, two further hindrances to northward expansion were the absence of coal and the distance from the economic centres of the industry—the port of Liverpool and the Manchester market. Thus, north of the coalfield edge, the only two cotton-working centres of any importance are Preston (deriving its soft water from the Millstone Grit of Longridge Fell) and Clitheroe (similarly supplied from Pendle Hill). Finally, it is noteworthy that the cotton industry has overstepped the flat watershed between the Roch and the Yorkshire Calder, Todmorden and Hebden Bridge being far more devoted to cotton than to wool.

Concerning the coalfield as a factor in the growth of the industry, reference has already been made (Chapter XIV) to the nature and occurrence of the seams. It is noteworthy here that the major centres of production were never in the vicinity of the principal cotton towns, but lay south-west thereof, in the Lancashire plain. The Bolton–Rochdale group, and the Rossendale group, especially, are removed from large mines. It is obviously, then, the mere existence of the coalfield, rather than the geographical distribution of the mining centres, which has been and is now of importance

(cf. Chapter XIX, p. 484, and Fig. 153). Less importance will be attached in the future, too, to the actual mining areas, for the use of electrical power transmitted from steam-power stations near the mines is making great strides (*vide supra*, p. 499, note 1).

The humidity of the atmosphere in Lancashire, although not the vital factor that it was formerly supposed to be, is a valuable asset.[1] For spinning a high relative humidity is required, as otherwise the threads snap under the strain put upon them in the process of drawing and twisting. Dampness causes the fibres to cling together. Even a slight drop in the relative humidity, due perhaps to an east wind, was sufficient to cause considerable inconvenience, and a long dry spell might prove very costly, for although from very early times—almost in fact from the introduction of the steam engine—artificial steaming or humidifying of the atmosphere has been practised, for long artificially dampened air was not as good as natural.[2] The value of this high humidity has been considerably enhanced by the increasing specialisation in the finer counts, for, naturally, the finer the thread the greater the liability to break under dry conditions. A high humidity is less important in weaving than in spinning, and it is noteworthy that the "East Lancashire" towns, north of the Rossendale upland, are somewhat more sheltered, and so drier, than those around Manchester.

Finally, a last result of the geological structure is the abundance of building material, so necessary in an area where great factories have to be erected. The sandstones of the Millstone Grit and Coal Measures have been employed for domestic and factory architecture, and more recently the Coal Measure shales have been dug in large quantities for brick making. Whilst the older spinning mills, and most of the weaving "sheds" north of Rossendale, are built of buff-coloured sandstone (now much soot-blackened), most of the modern mills are red-brick buildings,[3] which with their three or four storeys, chimney and tower stand-out prominently and give an occasional splash of colour to an otherwise drab landscape.

The development of associated trades is a natural accompaniment of the growth of any large and concentrated industry. It was indeed fortunate for the cotton industry that the principal seat of the heavy chemical industry in Britain should have grown up in the middle Mersey region, backed on the one hand by the saltfield of Cheshire, and on the other by the port of Liverpool, through which were imported the fats for soap making and the pyrites for sulphuric acid. Probably at first the two industries, cotton and chemicals, were interdependent, but the vast expansion of the

[1] Ogden, *loc. cit.*

[2] But this is scarcely true now, for modern humidifying apparatus is capable of control and an even humidity can be maintained.

[3] The bricks, which have a smooth, shiny surface, are known as "Accrington reds".

chemical industry has resulted in the textile trades now forming only a small part of the market for the produce of Widnes and Runcorn (cf. Chapter XXII). The growth of the engineering industry, too, especially that part of it devoted to the manufacture of textile machinery, was a natural corollary of the early inventions. Without it Lancashire could never have continued to lead the world in technical efficiency and in the production of the finest types of cotton fabric (cf. Chapter XVII, p. 411).

[Photo: Central Aerophoto Co.

FIG. 225.—A cotton mill town, Lancashire (Preston)

A creation of the industrial revolution and the Victorian era. Whilst this old-type housing is obsolete and disappearing, the mills are still characteristic with the four-storey spinning mill and the glass-roofed weaving sheds

The cotton industry would likewise have been stifled through the inadequacy of its transport system had not the railway come to its aid. The bulk traffic engendered by the cotton trade was fast outgrowing the capacity of the canals, and the monopolistic control exercised by the canal owners, the slowness of the transport, and the endless delays due to the locks, and in summer to lack of water and in winter to ice, led a group of merchants in Liverpool and Manchester to embark upon the construction of the railway to connect those two industrial foci (cf. Chapter XXVI). In the

30's the high-water mark of canal transport was reached; then railways began to supersede the stage coach and the barge for passenger and freight traffic, and by 1850 almost all the present railways were in existence. The outstanding features of the railway web of South Lancashire are a reflection of the distribution and organisation of the cotton industry—although, of course, it is not the cotton industry alone which has produced them. No less than three main lines connect the market and the port—the direct route across Chat Moss, the southern line *via* Warrington, and the northern line *via* Bolton. Manchester has a radial web linking it with all the major centres (see Fig. 273, p. 647), and an important link joins Liverpool to the weaving centres of East Lancashire. A more recent expression of the dominating position occupied by Manchester is the Ship Canal, completed in 1894, permitting large ocean freighters to dock 35 miles from the Mersey Bar.

PORTS IMPORTING RAW COTTON
(Million lb.)

	1913	Average 1927–30	1931	1935	1947	1948
Liverpool . .	1,690	1,106	744	855	591	652
Manchester . .	383	336	338	425	190	210
London . .	40	22	13	33	—	—

Mention should finally be made of the expansion of road transport between the ports, the mills, and the market. Motor lorries carrying, with trailers, from six to ten tons have, by reason of their greater flexibility as transporting media, taken much traffic from the railways. Loading up with raw cotton at the Liverpool or Manchester docks, they can deliver at almost any spinning mill within an hour or two, and are then free perhaps to carry yarn to a weaving mill, and afterwards cloth back to the Manchester warehouse in the same day.[1] Such mobility and speed are impossible for a railway wagon.

(*b*) *Scotland.*[2]—The growth of a cotton industry in Scotland, although resting on sound geographical foundations, was largely the result of the coincidence, in time, of two events of historical importance. At the beginning of the Industrial Revolution period flourishing linen and silk industries were already in existence, being especially well developed in the Glasgow–Paisley region (cf. Chapter XXI). Abundant supplies of soft water from the lime-free rocks of the Central Lowlands, a humid atmosphere favourable to the

[1] It has been calculated (W. Smith, "Trends in Lancs. Cotton Industry," *Geography*, XXVI, 1941, pp. 7–17) that on the average no fewer than six journeys are undertaken from raw cotton to finished piece-goods.

[2] See H. Hamilton, *Industrial Revolution in Scotland*, Chapter VI.

spinning operation, and a "deposit" of labour skilled in the manufacture of fine fabrics, thus provided a suitable ground in which the new industry could take root. Then the American War of Independence, by causing the sudden ruin of Glasgow's extensive trade with the Plantations—especially the tobacco trade—left without employment a vast amount of capital and organising ability which had been gained therein; and it so happened that this period, 1775–1780, coincided with the period of the great inventions in the cotton industry which we have already discussed. The manufacture of cotton thus provided a very appropriate new outlet for the capital and skill of the Lowlands. Actually, the use of cotton in fustian making probably began about 1769, and in 1780 muslins began to be made, using Indian spun weft; but it was not until the early 80's that the use of Crompton's mule enabled all-cotton cloth to be made from home-spun yarn, and the real boom in the erection of cotton spinning mills occurred between 1785 and 1795.

The widespread nature of the linen industry and the abundance of soft water and water power in most parts of Scotland resulted in the early cotton mills being scattered in many counties, although the Glasgow region naturally exercised a considerable influence by reason of its West Indian traffic (most of the cotton came before 1795 from these islands) and its linen and silk trades, on the location of new enterprises.[1] With the exception of one or two well-placed concerns which managed to survive for a considerable period, however (*e.g.* Catrine in Ayrshire, Deanston in Perthshire—both of which still exist to-day), most of the mills outside the Glasgow–Paisley region were comparatively short-lived; distance from the source of raw material (*i.e.* the port), and later from coal supplies, causing their eventual demise.

Just as in Lancashire, a new factor was introduced into the industry in the '90s—the steam engine. The expansion of this method of power production was not rapid in Scotland, partly because of the excellent water-power facilities which were being utilised, and partly because the engineering industry did not establish itself on the Lanarkshire coalfield as rapidly as in Lancashire, each new mill thus having to make its own machinery. Slowly but surely, however, the steam engine conquered the spinning industry, and the concentration of the mills upon the Lanarkshire coalfield became more marked. By the 1830's nearly all the spinning mills were to be found within 25 miles of Glasgow.[2]

In the weaving branch, of course, domestic labour continued

[1] The first cotton mill in Scotland was erected at Rothesay on the island of Bute in 1779. In 1787 there were 19 water-power spinning mills, distributed as follows: Lanark 4, Renfrew 4, Perth 3, Edinburgh 2, Ayr 1, Galloway 1, Annandale 1, Bute 1, Aberdeen 1, Fifeshire 1.

[2] Spinning mills, 1839: Lanarkshire 107, Renfrew 68, rest of Scotland 17. Glasgow alone possessed 98.

to produce the greater part of the output for some time after the spinning industry had been mechanised, and, as in Lancashire, the weavers enjoyed a period of great prosperity whilst yarn was so cheap. In 1831, although there were nearly 15,000 power looms in the Glasgow district, some 50,000 hand looms were still in use in the villages of Lanarkshire, Renfrew and Ayrshire, and hand-loom weavers remained an important section of the community until the 70's or 80's. The early specialisation of the linen and silk industries in fine fabrics naturally gave an impetus to the production of similar fine wares in cotton. Muslins and ginghams were the ordinary goods produced, but over half the looms, in about 1840, were employed in making the famous Paisley shawls (either all cotton, or cotton and silk), fancy muslins and decorated cloths. Here lay the greatest difference between the cotton industries of Scotland and Lancashire. Lancashire was thriving on coarse cotton cloths for the Indian market; the fine fabrics from Glasgow went mainly to the Continent.

The rapid rise of the cotton industry and its concentration in the Glasgow region were accompanied, as in Lancashire, by the growth of auxiliary trades. Pure water supplies and the facilities for importing raw materials gave rise to a chemical industry which could supply the bleaching and dyeing works which naturally sprang up in the wake of the cotton mills.[1] The ease of production of iron and coal resulted in the establishment of an engineering industry; but although at first this may have been intimately connected with the cotton trade, it soon expanded far beyond the limits set by the mechanical requirements of the factories, and took to the railway and shipbuilding branches (cf. Chapter XVII, p. 423). It was the extraordinary geographical basis of the iron industry, in fact (cf. p. 375) which prevented Glasgow from becoming a rival to Manchester, and which was largely responsible for the gradual decline of the Scottish cotton industry in the second half of last century. Iron, and later steel, came so to dominate the economic life of the lowlands, especially of the Lanarkshire coalfield region, that the cotton industry, built from the very beginning on the rather insecure foundation of specialisation in fine and peculiar wares, and so susceptible to changes of fashion,[2] and unable to take advantage of the expanding Indian and Far Eastern markets, was almost swamped.[3] The geographical suitability of the area for cotton manufacture remained unaltered, but the far greater suitability for iron and steel production resulted in the concentration on these trades at the expense of cotton.

[1] The dyeing industry was introduced into the Glasgow region by James Watt, who brought Berthollet's invention from France. (Cf. pp. 497, 540.)

[2] The manufacture of Paisley shawls, for example, collapsed between 1870 and 1880.

[3] *Vide* Hamilton, *op. cit.*, pp. 147–9.

The Present State of the Cotton Industry

(*a*) *Sources of Raw Material.*—The cotton industry in Britain was founded upon supplies of raw cotton from the Near East, as we have seen. Before the end of the seventeenth century, the West Indies began to rival the Levantine regions as the chief source of supply. London was the principal receiving port, most of the cotton making an overland journey between the capital and Lancashire. Liverpool, although its general trade was growing, was not important as an importer of cotton until the rise of the United States as a cotton-producing region. Towards the end of the eighteenth century, Glasgow also began to import West Indian cotton. Little expansion was possible in the supply of raw cotton from these regions, however, while the French were still in a position to intercept cargoes bound for Britain, and it so happened that a fresh source of supply in the Cotton Belt of the newly established United States became available at just about the same time as the Revolution in France temporarily upset the trading and industrial activities of that country. The cotton plant was of some importance in the agricultural economy of Georgia and the Carolinas by about 1790, and the invention of the saw gin, a machine for separating the fibres from the cotton seeds, in 1793, by making the medium-stapled American cottons much more readily usable, gave the signal for a very rapid expansion of cotton cultivation. The Southern States quickly superseded all other sources of supply, and since that time their produce has been the mainstay of the British cotton industry, and every fluctuation in their crop has been reflected in the prosperity or otherwise of the Lancashire mills.[1]

The following table shows the chief countries which send raw cotton to Britain.

RETAINED IMPORTS OF RAW COTTON
(Million lb.)

From	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
United States	1,471	857	838	442	602	453	329
Egypt	288	265	249	238	244	178	188
India	30	78	78	97	152	501	362
Brazil	57	24	20	37	59	137	178
Peru	38	72	83	64	61	44	62
Anglo-Egyptian Sudan	—	12	45	10	57	115	97
Other Countries	290	92	370	210	123	49	115
Total	2,174	1,400	1,483	1,098	1,298	1,026	1,005

[1] Includes Pakistan, 42. [2] Includes Pakistan, 28.

[1] *E.g.* the American Civil War, 1861–1864, or, more recently, the partial failure of the crop in 1921

Before the First World War, the United States and Egypt provided about 80 per cent. of the imports. Since then, however, there has been a great decline in the actual and proportional imports from the United States, accentuated since the Second World War by shortage of dollars; and an increase in the amount received from certain other territories, notably the Anglo-Egyptian Sudan and Brazil. The recovery of Japan and the changed political status of India and Pakistan have reduced British imports from the Indian sub-continent.

Raw cotton varies enormously in quality. The important factors determining quality include length and regularity, fineness, lustre, softness, strength, colour and cleanness. The fibres vary in length from about $\frac{1}{2}$ inch to $2\frac{1}{4}$ inches. In America, when the fibres are less than $1\frac{1}{8}$ inch in length, the cotton is referred to as short stapled; long-stapled cottons exceed $1\frac{1}{8}$ inch. In other countries the terms are relative. We may classify the various grades of raw cotton into three principal groups:

(*a*) Group I or Fine Cottons, including:

True Sea-Island, produced only in small quantities in the small islands off Georgia (United States) and in some of the smaller West Indian islands;

Georgia and Florida Sea-Island, generally grown on the coast lands of those States near the sea. Of roughly equivalent quality are the finest Egyptian cottons (Sakellaridis);

American "Long Stapled Uplands," grown mainly in Louisiana and Texas ($1\frac{1}{4}$ to $1\frac{3}{4}$ inch staple). Of about the same quality are Peruvian and the best West African cottons.

(*b*) Group II or American "Uplands"—the commonest and most abundant quality. Uplands are classified according to the International (U.S. official) standards into eight grades. In Group II are included much of the South American cotton as well as long-stapled Indian[1] and Russian.

(*c*) Group III or Short Native Indian, Russian, and Chinese cottons—short-stapled and harsh.

In general, it may be said that the longer the staple of the cotton the finer the yarn and fabric that can be produced from it. Yarn is graded in "counts." A count is the number of hanks, each 840 yards in length, which go to make up one pound avoirdupois. Thus the finer the yarn the higher the count. Ordinary American cotton of $\frac{7}{8}$ inch staple will produce yarn of about 20's counts, but the best Sea Island may give a yarn of almost spider's web fineness, counting more than 300 hanks to the pound, and counts of up to 200 are produced from the best Egyptian cottons.

(*b*) *Processes in the Cotton Industry.*[2]—The principles of cotton

[1] The bulk of the cotton imported by Britain from India and Pakistan does not exceed $\frac{3}{4}$ inch.

[2] See *The Cotton World*, ed. J. A. Todd (1927), p. 191.

manufacture resemble those which we have already described for the woollen industry (p. 477). The main processes are as follows:—

(1) After unbaling the raw cotton is passed through mixing and cleansing machinery (in which spiked rollers and air suction play important parts).

(2) Next, the carding machines give a final cleansing, remove the short unusable fibres[1] (*vide infra*) and deliver the cotton in slivers—ropes of clean separated fibres, held together by their natural cohesion.

(3) In order to remove irregularities of thickness and weight, several slivers are combined in a "drawing-frame" and drawn out into one, so that the fibres take up a position parallel to each other.

(4) The drawn slivers are passed through a succession of machines ("fly frames") which gradually reduce their thickness and prepare them for receiving the twist which will make them into yarn.

(5) One of two methods may be used in the spinning process. The simplest apparatus is the ring-frame (derived from Arkwright's "water-frame"), which spins continuously and is used chiefly for warp and coarser yarns. More complicated, needing more attention (for its operation is intermittent), but producing softer and better yarn, is the self-acting mule (derived from Crompton's invention).

(6) "Doubling" (twisting together of spun yarns) may be performed to ensure an even count being produced or to give strength to warp yarn; and all yarn destined for use as sewing thread, or in the lace and hosiery trades, is doubled.

(7) Weft yarn needs little or no further preparation, but the "twist" (warp yarn) must be transferred from the cops or bobbins of the spinner on to a winding frame ready for assembling on the warper's beam.

(8) After "beaming," the yarn on the beams is passed through boiling size and steam dried.

(9) The beam is then mounted in the loom, and weaving can commence.

(10) The "grey" woven cloth is then either disposed of as such, or is subjected to several finishing processes. Apart from dyeing, bleaching, and printing, the more important of these are calendering and mercerising. The calendering machine gives a smooth and shiny finish to the cloth. Mercerising consists of steeping cotton yarn or cloth in a bath of caustic soda in such a way that the shrinkage which would ordinarily

[1] In the production of fine yarns from long-stapled cotton special combing machinery is employed for this purpose between the carding and drawing processes.

result from such treatment is prevented. It produces a lustre almost equivalent to that of silk.

The short fibres removed by the carding machines are known as waste. They are worked up (sometimes mixed with short-stapled Indian cotton or even with wool) into coarse yarn (5's to 10's counts) for use in the manufacture of sheetings, blankets, towels, dusters, lamp wicks, and a host of other miscellaneous products.

(*c*) *Geographical Distribution and Specialisation.*—The extraordinary centralisation of the cotton industry in South Lancashire has rendered possible a degree of specialisation that is without parallel in any other branch of manufacture. Not only have the various processes of the industry tended to separate, financially and physically, but the relatively unfavourable situation of Lancashire with regard to raw materials and foreign markets has produced a further specialisation in the finer varieties of fabrics and in products for particular markets. The focus of this centralisation from the very beginning has been Manchester; but from being the principal producer the city has changed its rôle to that of commercial and financial centre. An industry which imported all its raw material from abroad and exported the bulk of its output naturally needed a greater amount of commercial organisation than an industry based upon local supplies and local markets; and Manchester, excellent route centre that it was, assumed the functions of bank and warehouse. The rapid growth which such a position entailed, combined with the city's increasing importance as a port, has had the effect of raising land values to such an extent that many of the older mills have migrated to the outer suburbs and to the smaller towns. Manchester is still the centre of the industry—no longer the producing centre, however, but the commercial centre.

Two of the outstanding features of the Lancashire cotton industry are the extreme specialisation of its constituent parts, and the feeble development of integration of any kind. At least six types of firm may be recognised: (1) the Liverpool merchants and brokers; (2) the spinners; (3) the yarn merchants; (4) the manufacturers (weavers); (5) the dyers and finishers; (6) the piece-goods merchants. Many of the producing firms further limit their activities, confining themselves, for example, to fine or coarse yarn, special fabrics, bleaching, sizing, or dyeing; whilst the activities of the Manchester merchants are similarly limited to certain markets.[1]

The distribution of the three main branches of the cotton industry, spinning (including carding), weaving or "manufacturing" (including winding), and finishing (bleaching, dyeing, and calendering)

[1] Chapman, *op. cit.*, Chapter VIII; G. C. Allen, *British Industries*, pp. 227–50; *Survey of Textile Industries*, pp. 15–30.

is indicated graphically in Fig. 226.[1] The economic basis of the separation of spinning and weaving, apart from the historical reasons given is not difficult to discover. It is due to two main

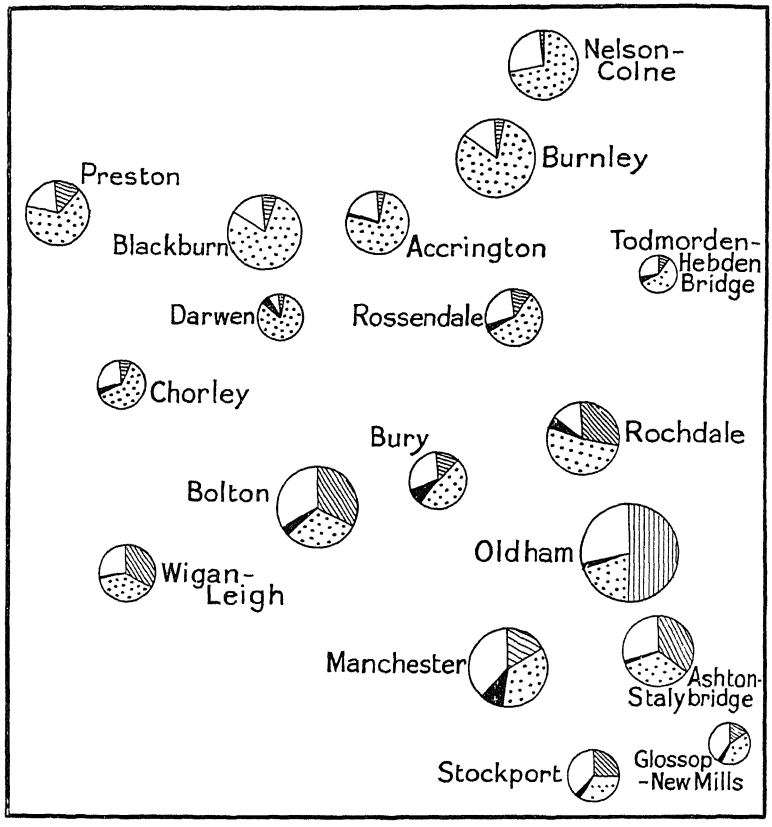

FIG. 226.—Distribution of Textile occupations in the cotton-working area, 1921

Circles are proportional in area to number of people employed; thus Oldham=66,000, Darwen=13,000. The sectors of the circles represent the proportion of the total engaged in the various branches of the industry. Ruled=Carding and Spinning (Census groups 363,365); dotted=Winding and Weaving (groups 367,370); black=Dyeing and Calendering (groups 381,384); blank=all other cotton-working occupations. The people have been grouped around the principal towns, thus Bolton includes Bolton C.B, and the parishes of Farnworth, Kearsley, Little Lever, Turton and Little Hulton; Rossendale, includes Bacup, Rawtenstall, Haslingden, and Ramsbottom. Notice the feeble development of spinning in the northern area, the prominence of weaving in the so-called "spinning" area of the south, and the importance of the finishing trades in the Manchester–Bolton–Bury region

causes. In the first place it is the result of the ever-increasing range of yarns and fabrics which can be produced. Few firms, without being unwieldy and uneconomic, could possibly manufacture all the many varieties of yarn and stuff, and so the business units have

[1] For an alternative method of demonstrating the distribution of spinning and weaving, by plotting the location of factories, see Fig. 62 of Wilfred Smith's *Economic Geography of Great Britain* (London, Methuen, 1949).

tended to remain small, specialising in certain types of product only. Secondly, the organising capacity necessary in the spinning industry is very different from that required in weaving.[1] The spinning branch is concerned with a narrower range of products, is more adaptable to large scale-production and horizontal integration, and depends for its market not only upon the local weaving industry, but also upon the fairly stable cotton industries of the Continent, and to an increasing extent upon the hosiery trades at home and abroad. The weaving trade, on the other hand, deals in a multitude of different styles of fabric, employing many different types of yarn, and depends largely for its prosperity upon a fluctuating, almost world-wide, market and upon the ability to foresee and cater for changes of fashion, both at home and abroad. There are still many firms which, whether through sheer momentum or through the desire to ensure the quality of the yarn which they employ, conduct both spinning and weaving operations, but the majority confine themselves to one branch only. The number of separate firms engaged in weaving is much greater than the number in the spinning trade. This is partly due to the greater tendency for amalgamation amongst spinning firms and partly to the extreme specialisation of the weaving trade.[2]

The spinning industry continues to be located principally in the towns of the early cotton-working area—the region of the valleys tributary to the Irwell and the Mersey, *i.e.* to Manchester. Although the "horseshoe" of towns stretching from Wigan and Leigh *via* Bolton, Bury, Rochdale, Oldham, and Stalybridge to Stockport is primarily devoted to spinning, weaving is by no means absent, and the spinning industry shows much specialisation which is incapable of geographical explanation. Thus Oldham deals mainly in medium staple American cotton, producing yarn of 20's to 60's counts. Rochdale's trade is similar. Bolton and Manchester, on the other hand, spin finer yarns from the best American, Egyptian, and Peruvian cottons; and in the Stockport district doubling becomes an important separate branch of the industry. North of the Rossendale upland spinning is of very small importance compared with weaving.

The spinning district—in which about 90 per cent. of all the spindles are located—suffered less during the depression of the 1930's than the weaving district, partly because of the additional outlet provided by the hosiery trades and partly since it is within this district that the bulk of the engineering and other industries of South Lancashire are located (cf. pp. 420, 456).

[1] Chapman, *op. cit.*, pp. 161–4. Cf. *Jewkes, loc. cit.*, pp. 105–6.

[2] Number of firms engaged in 1924 (*Worrall's Directory*, quoted in *Survey of Textile Industries*, pp. 24–6), spinning only: 620; spinning and weaving: 232; weaving only: over 900.

The weaving industry is far more widespread than the spinning, and is less concentrated in the major towns. There are many small weaving sheds outside the urban areas. Besides being dominant north of Rossendale, weaving employs as many or more people than spinning in most of the towns south of the upland, with the exception of Oldham.[1] Here again we find certain towns devoted to certain types of fabric. Within the Manchester province perhaps the chief weaving activity is concerned with the manufacture of goods from "waste," as at Rochdale and Heywood and in the Stockport–Stalybridge districts, but Oldham still retains something of the old fustian trade, and Bolton produces quilts. The towns in the Rossendale valley specialise in sheeting (made mostly from "waste"). North of the Fells we find Preston making fine shirtings, Blackburn and Accrington concentrating mainly on "dhooties"[2] and other cheap cloths for the Indian and Chinese trade, Burnley on long lengths of narrow cloth destined for printing, Nelson and Colne on "fancy" fabrics such as sateens, poplins, and brocade.

The finishing industry, comprising bleaching, dyeing and calico printing and numerous finishing processes, such as mercerising and calendering, remains centred in the Manchester province where it originally grew up.[3] It has been held there by the favourable situation with regard to pure water supplies, and by proximity to the great warehousing centre. The works are to be found alongside the streams which flow down from the Rossendale Fells and the Pennines, the rivers Goyt, Roch, Irwell and Bradshaw Brook being especially important in this respect. The chief centres are Manchester–Salford, Stockport, Bury, Bolton, and Rochdale (with Littleborough) and the smaller towns just north of Manchester—Radcliffe, Whitefield, and Middleton.

Those centres of cotton manufacture lying just off the edge of the main region in Derbyshire and Yorkshire for the most part resemble, in their industry, the Lancashire region which lies nearest. Thus the Glossop–New Mills group in north-west Derbyshire is devoted, like Stockport, to spinning, to the weaving of cloth from waste, and to the bleaching and dyeing industry. Farther north the Saddleworth–Dobcross area has specialities more akin to those of Oldham. A great tongue of the cotton industry stretches from Rochdale into the Calder valley of the West Riding, and whilst Todmorden and Hebden Bridge are more "cotton" than "woollen" towns, numerous woollen centres farther east also engage to a certain

[1] In 1936 some 74 per cent. of all the looms were in the main weaving district and 26 per cent. were located within the spinning district (W. Smith, in *Geography*, XXVI, 1941, p. 13).

[2] Long, narrow strips of flimsy cloth worn by male Hindus as pantaloons.

[3] About one-half of the 73,000 workers in the textile finishing trades in 1948 were in the North-Western Region.

extent in the manufacture of cotton.[1] Huddersfield and Halifax are the chief of these, but Sowerby Bridge, Elland, and Brighouse each have more than 10 firms engaged in the cotton industry. The main branches are cotton-doubling and weaving. Spinning did not develop to any extent, possibly owing to the lower average of relative humidity on the eastern side of the Pennines. Farther north still, the weaving industry of Nelson and Colne has overflowed into the Aire valley. Skipton is the principal centre, but Bradford also has a number of cotton mills, and others are scattered in the small towns which lie in the valley between these two—*e.g.* Keighley and Bingley. In this region weaving, especially of the Nelson–Colne specialities, is the principal activity.

Rather farther afield we find interesting "outliers" of the cotton industry in the region around the southern end of the Pennines, where the manufacture has survived because of the existence of allied industries. Scattered mills in the Macclesfield district of Cheshire deal in spinning and doubling and especially in bleaching, dyeing, and mercerising, the presence of the silk industry probably having encouraged the last-named activity. In Nottinghamshire, Leicestershire, and Derbyshire, the existence of the lace and hosiery trades has had much to do with the survival, as at Nottingham, Derby, Mansfield, Long Eaton and a few smaller centres, of cotton doubling and the manufacture of sewing thread.

The cotton industry in Scotland is but a shadow of its former self. The spinning branch has almost disappeared (except, of course, for the important manufacture of sewing cotton), and yarn is now obtained from Lancashire. Three types of activity remain. The last witness of the former trade in high-quality goods is the manufacture of poplins, muslins, ginghams, and fine shirtings, still carried on in Glasgow. Paisley shawls have given place to sewing thread in the making of which some 8,000, mostly women, are employed.[2] Lastly, the finishing trades still retain some of their former importance in the Glasgow region,[3] in the Vale of Leven (calico printing), and in north Ayrshire, by reason of the abundance of pure water and the proximity of the chemical industry—although most of their work is now performed upon fabrics which have been woven in Lancashire.

A few mills at Belfast continue to spin cotton, chiefly for admixture with flax in the production of special types of thread and table linen.

[1] Employment in the Yorkshire Region, 1948 (Census of Production): 7,542 in cotton spinning and doubling, 7,650 in cotton weaving.

[2] Enough thread is made each week in Paisley to encircle the earth 88 times! Employment, 1953: 8,436, of whom 5,672 were female.

[3] Nearly 13,000 people were employed in Scotland in textile finishing trades in 1948. The Vale of Leven industry is much declined, and a new industrial estate has come into being to relieve the unemployment thus created.

The Progress of the Cotton Trade

The British cotton trade experienced an almost uninterrupted growth from the period of mechanical inventions until the First World War, as we have seen. In the quinquennium before 1914 the enormous total of over 2,000 million lb. of raw cotton was being imported annually (cf. p. 508). Between the wars, however, the cotton manufacture suffered more from the effects of foreign competition, and of the world-wide depression, than perhaps any other industry, as the tables given below will show.

The inability of Britain to retain her hold of the world's cotton market during the first war allowed Japan to step in and capture much of the trade in the Far East, and the expansion of the industry in that country, and in India, where economic protection fostered the development of a cotton manufacture, did much to increase the problems and reduce the trade of the Lancashire producers.

Just as in iron and steel and in shipbuilding, the world supremacy of the British cotton industry has been dwindling for half a century or more. In the early 80's Britain possessed over half of the world's spindles. By 1914, the percentage had fallen to below 40, and in 1927 was little more than 33.[1] The advantage derived from being the first in the field is now lost, and some of the geographical factors which helped to localise the industry in Lancashire no longer operate. Cotton industries have grown up nearer to the plantations in the United States and in India and the Far East, and Lancashire has, as it were, cut her own throat by fitting out these new industries with machinery and so preparing them to compete with the Lancashire products for their own markets. It cannot be denied, however, that although the machinery industry in Lancashire has helped foreign competition, it has been a most valuable asset to its own region in providing on the spot the materials and the technical skill required in the development of new machines for an ever-increasing range of textile fabrics. The expanding industries in better-situated areas have rendered it increasingly uneconomic for Lancashire to try and compete in the market for cheap and coarse cloths, and as a result specialisation has taken place in finer fabrics. Thus in 1927 Great Britain possessed 67·5 per cent. of the world's mule spindles, but only 13·7 per cent. of the ring-frame variety—a reliable indication of the higher quality goods and the greater amount of skill necessary to produce them.[2]

The following tables present in statistical form the gloomy picture of the post-1918 cotton trade. In 1950, cotton manufactures represented but 7·3 per cent. of the total value of United Kingdom exports, compared with 25·6 per cent. in 1913.

[1] *Survey of the Textile Industries*, pp. 12–13, 150–51.
[2] *Survey of the Textile Industries*, p. 13.

EXPORT OF COTTON YARNS

(Million lb.)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Germany	52	35	41	33	30	3	5
Netherlands	39	44	35	23	15	7	4
Switzerland	9	8	8	6	5	0	1
France	5	5	5	3	1	1	1
Belgium	5	5	7	4	5	1	1
India	37	26	19	11	11	21[1]	31[1]
Other countries	63	46	52	54	75	49	55
Total	210	169	168	134	142	82	71

[1] India and Pakistan.

EXPORT OF COTTON PIECE GOODS BY VARIETY

(Million Linear Yards)

Variety	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Grey, unbleached	2,357	1,252	943	289	323	96	99
White, bleached	2,045	1,306	1,228	631	589	222	193
Printed	1,231	681	556	322	455	340	321
Dyed in the piece	1,151	750	760	456	535	239	209
Coloured cottons	290	185	153	90	111	61	54
Total	7,075	4,179	3,667	1,790	2,013	957	867

EXPORT OF COTTON PIECE GOODS BY COUNTRIES

(Million square Yards)

Country	1913[1]	Average 1921–25	Average 1926–30	1931	1935	1949	1950
India	3,057	1,393	1,382	390	543	113[4]	73[4]
Egypt	267	214[3]	137	71	36	3	3
China	573[2]	244	141	41	8	—	—
Argentina	199	146	131	93	134	11	4
Australia	168	169	162	122	118	124	115
Total (sq. yds)	7,075	4,021	3,579	1,716	1,948	903	815

[1] Linear yards.

[2] Exclusive of Hong Kong, Macao and leased territories—elsewhere these are included.

[3] 1923–25 only.

[4] India and Pakistan.

PORTS EXPORTING COTTON YARN AND GOODS

(Million £'s)

	1913	Average 1927–30	1931	1935	1947	1948
Hull	5·2	9 9	6·0	5·9	2·2	4·2
Liverpool	71·3	67·7	26·0	32·2	49·7	85 8
London	9·9	9·7	5·7	6·0	7·6	10·5
Manchester	14·0	15·0	5 5	4·4	6·1	10·6
Southampton	6·2	7 8	3·4	2·9	2·6	4·8
Glasgow	5 8	6 7	3 0	3·3	4 0	7·3

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CHAPTER XXI

THE TEXTILE INDUSTRIES: OTHER TEXTILES[1]

THE textile industries, other than wool and cotton, and the secondary industries, which together gave employment in 1948 to 214,000 people, fall naturally into three groups: (1) those depending mainly for their raw material upon the products of the major industries, cotton, wool, and worsted, and more recently, rayon—that is, the manufacture of lace and all kinds of knitted goods which come under the general term "hosiery" or, to use the convenient American term, "knitwear"; (2) those depending upon home-grown fibres or upon material imported from abroad—i.e. the linen, jute, and silk trades; (3) those depending on the "artificial" fibres—rayon and nylon. This division is not a hard and fast one, however, for outside the comparatively isolated and independent linen and jute industries there is a great deal of interdependence between the lace and hosiery trades and silk and rayon manufacture. If we examine the geographical distribution of the various branches, we shall find that several different types of factors have been involved in their localisation.

(1) In the case of linen, proximity to flax-growing areas led originally to the rise of Ireland and the Scottish Lowlands as manufacturing regions. In the Lowlands the growth of other textile occupations and of heavy industries in the west resulted in the confinement of the linen trade to the eastern region—a situation confirmed by the ease of importing flax and hemp from the Baltic countries. In Ireland the events of the Industrial Revolution conspired to localise the industry upon Ulster.

(2) The jute industry attached itself, quite naturally, to the allied linen and hemp trades of the Dundee province,[2] and it has attained but small dimensions elsewhere.

(3) The localisation of much of the silk industry in south-east Cheshire and north-west Staffordshire is not easily explicable on a purely physical basis. Its expansion was due to the pre-existence of a textile smallware and button-making trade, combined with facilities for water-power development.

(4) In Leicestershire, Nottinghamshire, and Derbyshire, the lace and knitwear industries are a result of specialisation in an area

[1] By S. H. Beaver.

[2] It was a Dundee manufacturer who, during a temporary shortage of hemp supplies, experimented with jute as a substitute.

which from very early times has been associated with the woollen and worsted trades, and parts of which, owing to the presence of water power, had developed silk manufacture or the spinning of cotton.

(5) Rayon and nylon manufacture are really chemical industries, depending in the case of rayon on imported wood pulp and cotton linters, and a very large water supply, and in the case of nylon, on chemicals derived from coal or petroleum. But their products, "artificial" fibres, are the raw materials of textile industries which in general have attached themselves to pre-existing textile centres, where suitable skilled labour could most easily be obtained—as in south Lancashire, west Yorkshire, the Nottingham–Leicester province, and the Macclesfield–Leek district.

(6) Finally, there are numerous isolated centres of the minor textile industries to be found, as in East Anglia, in the West Country, and in south-west Scotland, where certain specialities are all that remain of once flourishing trades in wool and worsted, silk, or cotton.

With the exception of the artificial fibres, which are products of the twentieth century, all the minor textile industries have long histories. Many features of their early distribution are inexplicable except by the chance settlement of Flemish or other foreign craftsmen; and the geographical and historical factors which contributed to their development in most cases have long since ceased to operate. Without going into an immense amount of historical detail, then—a task which is here impossible—it is difficult to give more than a sketchy account of their origin and growth; and many of the curious features of their distribution must be passed over merely as examples of industrial momentum.

EMPLOYMENT IN "OTHER TEXTILE" INDUSTRIES, 1948[1]

Textiles	Total Employment	Chief Regions ('000)
Rayon, Nylon, and Silk	78,582	N.West (34·9), N. Mid. and Mid. (26 8), Yorks (8·8)
Linen and Soft Hemp	11,179	Scotland (9·9)
Hosiery	94,987	N. Mid. (60), Scotland (13·5)
Lace	12,324	N. Mid. (7·9)
Jute	17,215	Scotland (17)

[1] Census of Production, Great Britain only.

Lace.[1]—Lace was being made in Nottingham, chiefly as a female domestic occupation, in the sixteenth century, and a fillip was probably given to the trade by the arrival early in the seventeenth

[1] See *Victoria County History, Nottinghamshire*, II, pp. 358–363. Also W. Felkin, *History of Machine-wrought Hosiery and Lace Manufactures*, 1867 (very detailed).

century of skilled artisans from Flanders, who introduced the working of pillow lace.[1] Little progress was possible, however, until the invention of mechanical aids to manufacture. Three mechanical appliances have probably done more than anything else towards developing the possibilities of lace making. Between 1770 and 1790 numerous attempts were made to adapt the stocking frame of the hosiery industry to the production of new meshes, with the result that

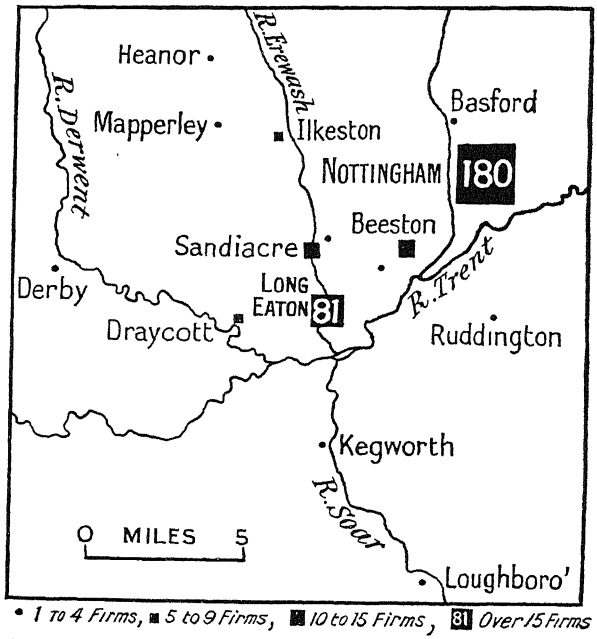

FIG. 227.—The lace-making province of the Nottingham area
Numbers refer to inter-war years

by 1810 some 15,000 people were employed in lace working. The invention of the bobbin-net machine by Heathcote in 1809 gave a further impetus to the industry, and during the next twenty years the population of Nottingham and its surrounding villages rose from 47,000 (1811) to 79,000 (1831). Then, in 1834, Leavers adapted the Jacquard principle to the lace-frame, thus enabling patterns to be produced mechanically instead of being sewn in by hand. During this period the bulk of the work was of a domestic nature, and large numbers of children were employed in preparing the material for their parents. Most of the cotton yarn used came from Manchester, but the doubling was done in Nottingham. The factory system developed but slowly,[2] and the (now defunct) system of hiring out

[1] Pattern produced by passing thread round pins stuck in a cushion or pillow.
[2] In 1862, of 120,000 people employed in the lace industry, only 4,000 came under the notice of the Factory Acts.

machines to workpeople has resulted in the existence, within the industry, of a great number of small firms, several of which are frequently to be found, renting their floor space and power, within a single mill.

The lace trade has, of course, been subject to great fluctuations in accordance with changes of fashion, and it may be said that on the whole it has tended to decline since the Victorian era.[1] A remarkable concentration upon the Nottingham region has been its outstanding feature almost from its inception, an excellent example of the cumulative growth of an industry (Fig. 227). After the city of Nottingham, Long Eaton is the next important centre, but Sandiacre, Beeston, and numerous other small towns also participate.[2] With the exception of a few isolated West country mills (*e.g.* Chard, and Honiton) the only other noteworthy region is Ayrshire, where lace making, principally of curtain nets, has developed out of the specialised and declined cotton industries of the Glasgow region, which we have already described. Newmilns and Darvel—old water-power sites on the Irvine river—are the most important centres.

Knitwear.—The present-day "hosiery" industry deals with such a variety of products that hosiery proper now forms only a relatively small part of it, knitted underwear and outer garments (pullovers, bathing suits, even frocks and costumes) providing a constantly expanding market. It seems advisable, therefore, in order to avoid confusion of terms, to designate this industry "knitwear." For the first 300 years of its existence, however, the industry was primarily devoted to the production of hose.[3] This hosiery manufacture, making use of worsted and silk, dates from the invention—or perhaps perfection—of the knitting frame, probably by William Lee, of Calverton, near Nottingham, about 1589. It grew up, slowly replacing hand knitting, in Nottinghamshire and in the adjoining counties of Leicester and Derby—possibly aided by the local production of worsted yarns from the long-woolled Leicester sheep—and also in London, where no doubt the proximity of the silk industry (*vide infra*) and the great local demand for all kinds of clothing were responsible for its progress. The London industry began to decline from about 1730, and most of the machines, possibly because of cheaper labour or cheaper rents, found their way to Nottingham and Leicester. Strutt's invention of a machine for producing ribbed

[1] Employment in lace industry—1907: 25,000; 1924: 17,000; 1930: 14,000; 1948: 12,000.

[2] K. C. Edwards, *Geographical Factors in the Development of Nottingham.* Thesis approved for the degree of M.A. in the University of London (unpublished), 1930. *Idem* "Nottingham," *Geography*, XX, 1935, 85–96.

[3] *Victoria County History, Nottinghamshire*, II, 352–358; Felkin, *op. cit.*; F. A. Wells, *The British Hosiery Trade: its History and Organisation*, 1935 (see especially Chapters 1 to 3).

hose, in 1758, gave an impetus to the trade, especially in Derby, in which town the machine was first erected. The three principal centres became concerned with different types of hosiery. Nottingham was the first to make cotton stockings from Indian spun yarn, in 1730, and its later connection with Arkwright, Hargreaves, and the early cotton-spinning industry (cf. Chapter XX, p. 495) made it the chief cotton-hosiery town, although silk was also employed to a large extent. Derby, the home of the first English silk mill (*vide infra*), developed the manufacture of silk hose; and Leicester, always more concerned with long wools than with cotton or silk, specialised in worsted hosiery.

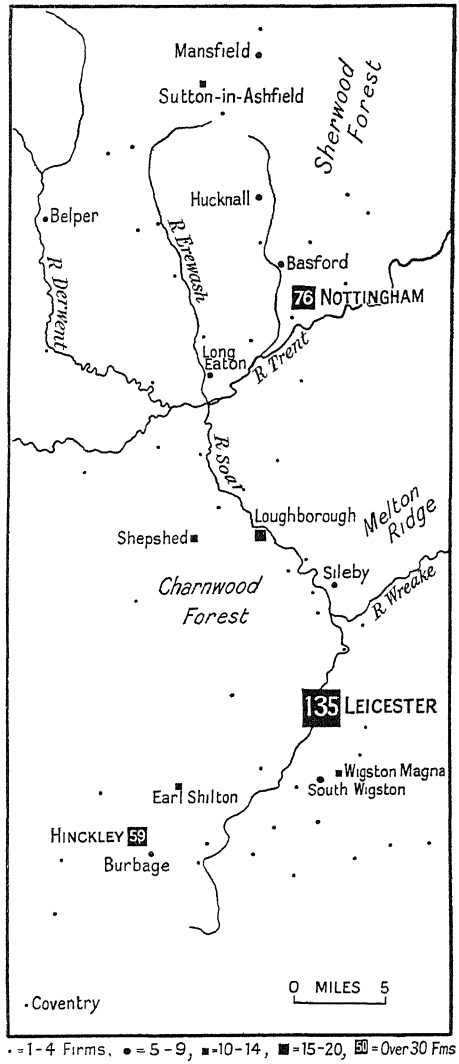

FIG. 228.—The knitwear province of the south-east Midlands

Numbers refer to 5 inter-war years

The present-day manufacture of knitwear forms an interesting link with the cotton, woollen, silk, and rayon industries, for the finished or semi-finished products of those trades form its raw material. The introduction of trousers at the expense of knee-breeches almost killed the silk-hose business, but the cheapening of the manufacture of silk and its use, together with rayon and nylon in the production of ladies' hosiery, provided a welcome revival. The use of cotton, wool, silk, and artificial silk for knitted underwear, and of wool especially for outer garments, has greatly expanded the market for knitwear, and the growth of the industry has continued during

the past decade, despite the industrial depression, until the number of people employed is well over 100,000 (see table on p. 459). The "knitwear province" is shown in Fig. 228. Dominated by Leicester and Nottingham, the industry is seen to be grouped about four nodes. In the south, Leicester and Hinckley are the principal centres, together with the Wigstons and numerous villages south of Leicester. Leicester itself participates in all branches of the trade, but is the leading centre for the use of spun nylon and wool mixtures. In the lower Soar valley, Loughborough, Shepshed, and a number of small villages are engaged in the industry; and Nottingham is the focus of the trade in the Erewash and Leen valleys. The last, and smallest, group centres on Sutton-in-Ashfield and Mansfield. At Derby, with the decay of the silk industry and the growth of engineering, the industry gradually declined; it has been revived in a highly specialised form—the manufacture of elastic webbing and bandages. As a broad generalisation, it may be said that the northern half of the province (the Nottinghamshire–Derbyshire portion) is as much associated with silk as with wool in its hosiery manufacture; the southern portion (Leicestershire) has always been concerned rather more with the use of woollen and worsted yarns, and is now very important for nylon. Into further detail than this it is impossible to enter.

Outside this main knitwear province, several other centres of the industry are to be found, mainly in association with other textile trades. Several towns in south Lancashire and the West Riding—Manchester and Keighley are the chief—have knitting mills, as have also the silk-manufacturing centres of Cheshire and Staffordshire—Macclesfield, Congleton, and Leek. In Scotland, Glasgow, Kilmarnock, and Stewarton, together with numerous other Ayrshire towns, carry on a trade which had developed out of the decayed cotton industry of that area; and Hawick has developed woollen knitwear as a sideline to its tweed-cloth industry. Numerous other towns in England and Scotland have small knit-wear factories—for bulky raw material is not required, and steam or electric power is only needed on a comparatively small scale.

We turn now to a consideration of the minor textile fibres and the industries based upon them.

Linen.[1]—Flax-growing and the manufacture of linen have been carried on in England, Scotland, and Ireland, and since the industries in each of these countries have had little relation to one another it will be convenient to treat them separately. In each country, however, we shall find that little is known of the origin of the industry, that a considerable advancement was brought about by the influx of foreign refugees, and that parliamentary action, in the form of duties,

[1] See A. S. Moore, *Linen* (1922); and A. J. Warden, *The Linen Trade Ancient and Modern* (1864).

and historical events, such as the American Civil War, have also contributed to the development of the industry.

England.—Flax was certainly being grown in England in the twelfth century, and late in the fourteenth century a colony of linen weavers, brought by Edward III from the Netherlands, was settled in London; in the fifteenth century Norwich was the centre of the linen trade. Little expansion was possible, however, whilst the woollen industry was receiving such careful attention from the Government; no encouragement was given to linen lest it should interfere with the wool trade, and it was not until the rise of the cotton manufacture with its accompanying demand for linen warp yarn, that any great advance was made. Flax growing and linen manufacture were domestic industries, scattered over many parts of the country, notably in South Lancashire, but the quality of the product was poor, largely owing to inadequate knowledge of, and lack of care in, the preparation of flax, and in consequence a great deal of fine linen was imported from France. The introduction of spinning machinery in 1787[1] and the development of steam power after about 1820, resulted in the concentration of the industry in the West Riding, where it reached its maximum in the 'fifties. Leeds alone possessed nearly half of the 441,000 spindles in England and Wales in 1856. The increasing dominance of the wool-textile industry, and the much greater development of linen and its allied fibres in Ireland and Scotland led to the decline of the Yorkshire industry; and at the present time the manufacture of linen in England is practically extinct.

Scotland.[2]—Linen was the principal export of Scotland in the sixteenth century, and its manufacture was a widespread domestic occupation. After languishing for a period, it experienced a considerable revival in the eighteenth century after the union with England, largely as the result of state encouragement. A board of trustees was set up in 1727, with funds and power to help flax growing and the linen trade—and this remained in existence for nearly a century. A little colony of French weavers from St. Quentin was established at Edinburgh in 1729, and later, Irishmen and Dutchmen were brought to Scotland to teach improved methods of production and manipulation of flax and linen. At first the product was of coarse quality, and most of the export went to the American Plantations, but from the 'forties onwards finer varieties of linen cloth began to be copied from our German competitors. The domestic manufacture of the period was widespread, but with the growth and capitalisation of the industry certain divisions began to be apparent, much of the spinning being done in the northern counties (*e.g.* Banff, Aberdeen) whilst the weavers, although very

[1] First machine erected in 1787 at Darlington.
[2] See Hamilton, *op. cit.* Chapters IV–V.

scattered, tended to congregate in the commercial and finishing centres of the Lowlands, where, as at Perth, Glasgow, Edinburgh, Dumbarton, and several places in Fifeshire, large bleaching fields were laid out. To an increasing extent, too, the eastern part of the Lowlands—Forfarshire (Angus)[1]—began to specialise in the coarser types of cloth, whilst Lanarkshire and Renfrew developed the manufacture of French lawns and cambrics,[2] using imported yarn.

The phenomenal growth of the cotton industry in the western portion of the Lowlands during the last 20 years of the eighteenth century had a profound effect upon the linen trade. The manufacturers of fine French and Italian varieties of cloth in the Glasgow–Paisley region were the first to take up the new fibre, and the result was an almost complete extinction of the linen industry in that area. Just at this period, however, flax-spinning machinery was introduced, and the linen industry in the eastern counties, aided by the presence of water-power, and, after the application of steam power, of coal, entered upon a period of rapid growth, in the 1820's and 1830's. The county of Angus, with Dundee as its chief town, soon became the most important, with the adjoining county of Fife not greatly inferior. In 1836 Scotland possessed 170 flax-spinning mills (80 per cent. of them in these two counties) employing over 13,000 people. The decline of domestic spinning was not paralleled by a similar contraction of the home weaving industry. Flax fibres are inelastic and were not easily worked by mechanical power, so that, although attempts were made to introduce power looms in the 'twenties, their adoption was not general until after 1850, when Dundee, Coupar Angus, Brechin, Kirkcaldy, Montrose, and Aberdeen became important weaving centres. The American Civil War, by almost strangling the cotton trade, gave a distinct fillip to the manufacture of linen, but the prosperity was short-lived, and a steady decline set in. Possibly aided, however, by the allied jute and hemp industries, and by the facility for importing Baltic and Belgian flax (for flax cultivation in Scotland has practically ceased), the linen industry has maintained itself to a far greater extent than in England.

Ireland.[3]—Of very early origin, the manufacture of linen in Ireland was for a long period given no encouragement as being prejudicial to the wool trade. It is thus of little moment until the seventeenth century, towards the end of which legislation laid for it a permanent foundation by prohibiting the export of wool from Ireland except to Britain (lest the cheap Irish labour should undercut England's wool trade in foreign markets), and by admitting Irish flax and linen into

[1] *E.g.* Dunfermline (Fife), long renowned for table linen.

[2] As late as 1767, 40 skilled craftsmen were brought from France to teach the spinning of fine yarns, and settled at Anderston.

[3] See H. W. Ogden, "The geographical basis of the Irish Linen industry," *Journ. Manchester Geog. Soc.*, XLV, 1934–1935, 41–56.

England free of duty. Its growth was materially aided, too, by the influx in 1685 of Huguenot refugees, who settled mainly in Protestant Ulster and in Dublin (those in Dublin being chiefly silk and poplin weavers); whilst the encouragement of flax-growing by Charles II and the improvement of the methods of cultivation and bleaching by the Huguenots, were other contributory factors. As in Scotland, a Board of Trustees was established to assist the growing of flax and to preserve the quality of the produce by grading and marking all cloth; like the Scottish board, this continued in action for more than a century. The vast expansion of the trade during the eighteenth century[1] was achieved entirely without mechanical power, and until about 1830 the linen manufacture was a cottage industry; only in 1828 was the first flax-spinning machine erected in Belfast, and although power looms began to appear from 1850 onwards, hand-loom weavers remained an important section of the linen operatives until the First World War. Power machinery rendered certain the dominance of the Ulster region, by reason of its nearness to imported coal supplies and to the port of Belfast. Over the rest of Ireland production, except perhaps for home use, has practically ceased.

Processes in the Linen Industry.—Flax is by no means so simple a fibre to deal with as cotton, and it is very liable to be injured by careless treatment during the preparatory processes. The pulled flax must first be retted in water in order to remove soft tissues and gummy matter and to facilitate the separation of core and fibre. It is in this process that ignorance or carelessness on the part of the farmer may lead to much damage. The retted stalks are then scutched (beaten) to remove the woody core; the waste fibre produced thereby is called "tow" and is used for making twine and canvas. After scutching, about 5 per cent. by weight of the original flax plant remains. Before spinning, the fibre must be submitted to roughing and hackling processes—i.e. combing out short fibres (producing more "tow"), untangling and parallelising the fibres, and then cutting out the middle (best) part of each length. The "line" (as distinct from "tow") is combined by machinery into slivers, which are further drawn out in a drawing frame and wound on bobbins for spinning. In Scotland dry spinning is mostly practised —giving strong yard for towelling and for weft in mixed goods. In Ireland, for finer and more even yarn, the rovings are passed through hot water before spinning. The spun yarn is doubled for use in the lace, tailoring, carpet, and fishing-net trades; and yarn for fine linen goods is bleached and boiled before being woven. The weaving process needs no comment. To a greater extent than any other textile, linen derives benefit from bleaching. Grass bleaching is still

[1] Annual export 1700: about 200–300 thousand yards. 1800: about 30–40 million yards.

done in Ireland, away from the smoky towns, but most of the linen is bleached and finished by chemical and mechanical methods.

The products of the linen industry are four in number: (1) *Yarn*; (2) *Brown cloth* (unbleached)—canvas, duck, and drills; (3) *Fully bleached*—for shirtings and sheets, damasks and cambrics; (4) Articles made from fully bleached cloth—sheets, handkerchiefs, table-cloths, and so on, in immense variety, plain and embroidered.

Raw Materials.—The Irish flax crop being insufficient to supply the linen industry of Ulster and the Scottish crop being almost negligible, a considerable import of raw flax and spun yarn is necessary, as the tables below show.

Before 1914 Russia supplied the bulk of the requirements, but between the Revolution and 1932 only a very small proportion came from the U.S.S.R. This proportion, however, notably increased during the 1930's, but declined to nothing during the Second World War and has not yet recovered. The chief flax-growing area of old Russia lay in the north-west, and in the erstwhile republics of Latvia, Estonia, and Lithuania. The main source now is Belgium, and the adjacent parts of France and Holland. From Belgium also most of the imported yarn—mainly coarser varieties in the production of which Ireland cannot economically compete—is derived.

IMPORTS OF FLAX AND LINEN YARN
(Thousand cwts.)

Variety of Product	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Raw Flax	1,686	564	708	579	679	458	650
Tow or Codilla	364	140	132	286	444	132	274
Flax Yarn	248	89	143	138	20	17	40

PORTS IMPORTING FLAX AND LINEN YARN
(Thousand cwts.)

Town	1913	Average 1927–30	1931	1935	1947	1948
Belfast	1,363	492	696	681	331	312
Dundee	451	182	113	288	100	100
Leith	266	149	102	80	—	—
Aberdeen	106	45	12	1	—	—
Glasgow	33	28	15	16	20	20
London	70	16	38	8	—	—

FLAX PRODUCTION OF NORTHERN IRELAND
(Thousand cwts.)

1913[1]	Average[1] 1926–30	1931[1]	1939[2]	1948[2]	1949[2]
253	116	28	90	80	100

[1] International Yearbook of Agricultural Statistics—figures converted from quintals.

[2] Scutched fibre (source: Ulster Year Book, 1950).

IMPORTS OF FLAX, TOW, AND LINEN YARN BY COUNTRIES
(Thousand cwts.)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
U.S.S.R.[1]	1,583	74	34	120	458	13	68
Estonia	—	79	67	6	66	—	—
Latvia	—	168	319	442	168	—	—
Lithuania	—	12	22	2	19	—	—
Netherlands	33	40	46	17	64	151	115
Belgium	517	259	378	340	343	410	575
France	42	17	38	36	5	8	23

[1] Russia prior to 1921.

The Linen Industry To-day.—The United Kingdom possesses about one-third of the world's flax spindles, and Ulster is the greatest linen-manufacturing region of all. Belfast is the hub of that industrial area, and three-quarters of the mills are within 30 miles of the city. Belfast dominates the linen industry to an even greater extent than Manchester does the cotton industry, for it is the chief manufacturing centre as well as being commercial focus and port. Other important centres are Lurgan, Banbridge, Portadown, Ballymena, and Lisburn, but many of the small towns are associated in one way or another with the industry (Fig. 229). There is some separation of spinning and weaving, many firms confining themselves to one branch only, but the division is not so marked, either economically or geographically, as in the case of the Lancashire cotton industry. The

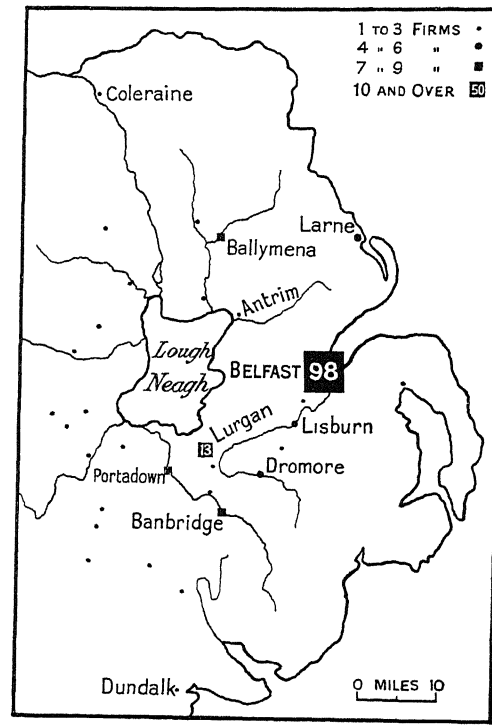

FIG. 229.—The Irish linen province
Figures refer to inter-war years

Irish linen industry has suffered considerably from the competition of more cheaply produced yet artistically finished cotton goods, and from the decline in the demand for linen blouses and embroidered work; but much has been done since 1918[1] to improve the quality of the Ulster flax by scientific approach to the problems of cultivation and retting. Many firms, moreover, are now concerned with the spinning and weaving of staple rayon (see p. 537) as well as flax.[2]

Whereas Ireland has always been famous for its fine quality linen, eastern Scotland has for a long period been associated with the coarser types of product. This is partly, no doubt, due to the remarkable development of the manufacture of the coarser fibres, jute and hemp, in that region. Of a number of towns in the counties of Angus, Perth, and Fife, devoted to the linen industry, the chief are Kirkcaldy, Dunfermline (famous for its damasks), Dundee, Forfar, and Brechin. Most of the linen yarn is obtained from Belfast.

In England, Manchester is the only town having a linen industry of any considerable importance. Numerous other towns, however, use flax in combination with tow and hemp for the production of the coarser varieties of linen cloth.

Like the cotton trade, the linen industry depends primarily upon the export market. Only about 20–30 per cent. of its produce is retained in the United Kingdom. Unlike cotton, however, its chief market is North America, and it is thus an important dollar-earner. The United States has for many years taken over one-third of the total exports, and Canada has been high on the list.

EXPORT OF LINEN YARN AND MANUFACTURES[1] BY COUNTRIES

(Thousands of £'s)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
China . . .	38	85	201	293	343	7	7
U.S.A. .	3,962	5,906	3,639	2,496	2,142	3,525	6,559
Brazil . . .	212	295	323	97	208	2,473	1,171
Argentina . .	334	340	264	91	134	671	162
South Africa .	145	224	252	136	349	683	588
India . .	254	320	308	163	147	235	76
Canada . .	690	911	1,066	565	617	702	1,070
Other countries	3,829	4,359	4,124	2,084	3,252	7,903	10,110
Total . .	9,464	12,438	10,177	5,925	7,192	16,200	19,741

[1] Including hemp manufacture.

[1] The "Linen Industry Research Association" was formed just after the First World War. It had Government backing and included all the principal firms in its membership.

[2] See *Belfast in its Regional Setting*, p. 151 (British Association Handbook, 1952).

Belfast cannot afford to relax her grip on the foreign market, for formidable rivals in Belgium, France, Germany, and more recently Japan, are always ready to step in and seize the trade.

Hemp and Jute

The term hemp is applied very loosely to a number of fibres. Soft, or European, hemp is obtained from the stalk of the hemp plant, like flax, but large quantities of hard fibres, also known as hemp, are obtained from the leaves of sub-tropical or tropical plants—as manila hemp from the Philippines, phormium from New Zealand, sunn hemp from India, and sisal from West and East Africa and Mexico. The hemp fibres can be used for the coarser varieties of "linen," and in addition are much in demand for the manufacture of rope and twine, canvas, and sacking. All the hemp used in Britain has to be imported. The hemp-using industries are widespread, but tend to be concentrated (*a*) in the linen-manufacturing areas of north-eastern Ireland and eastern Scotland; (*b*) in the textile districts of south Lancashire and the West Riding, and (*c*) at the principal ports where there is a constant demand for rope and sacking.

Jute is a coarse fibre which will not bleach but dyes well, and although strong, perishes on exposure. It owes its lead among the minor textile fibres to its cheapness, which is due partly to the great production per acre and partly to the ease with which it can be prepared, spun, and woven by modern methods. The jute industry in Britain grew out of the flax and hemp manufacture of the Dundee region, whither Indian jute began to make its way in the 'thirties of last century.[1] Its progress at first was slow, owing to the difficulty

IMPORT OF RAW JUTE
(Thousand cwts.)

	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Total Import .	7,016	3,095	3,749	2,955	3,635	1,910	2,253
From India	6,951	3,054	3,628	2,894	3,634	981	86
From Pakistan						929	2,166

PORTS IMPORTING RAW JUTE
(Thousand cwts.)

Town	1913	1931	1935	1947	1948
London . . .	2,564	488	668	100	300
Dundee . .	4,350	2,424	2,742	1,220	1,520

[1] W. H. K. Turner, "The Evolution of the Pattern of the Textile Industry within Dundee," *Trans. Inst. Brit. Geog.*, 18, 1952, 107–119.

EXPORT OF JUTE MANUFACTURES BY COUNTRIES (including yarn but excluding cordage, etc.)

(Thousands of £'s)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Netherlands .	148	154	289	123	185	*	*
Belgium .	104	72	174	44	100	*	*
U.S.A. .	1,653	1,891	1,525	499	709	264	508
Brazil . . .	299	322	388	214	127	*	*
Argentina . .	673	549	371	73	104	*	*
South Africa .	85	147	146	74	75	155	132
Canada . .	487	412	464	150	147	*	*
Other countries	1,890	1,964	2,001	1,059	1,207	*	*
Total . .	5,339	5,511	5,358	2,040	2,654	3,453	4,314

*Not available.

of manipulating the fibre and of adapting the flax machinery to its use, but in the 'fifties the industry became so profitable that most of the Dundee spinners and weavers changed over from flax to jute and the new fibre became the principal material for sackcloth and hessian, and was used with hemp to produce coarse sheeting. Another important use found for it was in the manufacture of carpets and linoleum; the town of Kirkcaldy has become the chief centre in Britain for floorcloth manufacture. A very large proportion of the jute industry is still centred at Dundee, very few other places, except one or two nearby towns (*e.g.* Tayport) and a few of the principal ports, having adopted it. The tables above illustrate the jute trade.

Silk.—Judged by the length and fascination of its history,[1] the silk industry deserves a chapter to itself. Although a revival has taken place recently, collaterally with the extended use of artificial silk or rayon, the prosperous days of the industry were those of the eighteenth and early nineteenth centuries. Silk, like wool, has been worked by domestic labour in many parts of Britain (Fig. 230), but as its manufacture developed after that of wool the existence of wool-working centres tended to influence the siting of the early silk industry; and in subsequent periods other textile industries, such as hosiery, cotton, and the woollen industry of the post-machinery age, have exercised an attraction.

Although earlier records exist, the real beginning of the silk industry dates from the sixteenth and seventeenth centuries when skilled Flemish and French craftsmen were seeking refuge in Britain from persecution on the Continent. In the sixteenth century Flemish weavers were making bombazines in Norwich and Colchester

[1] See Sir F. Warner, *Silk Industry of the United Kingdom* (1921)—very detailed.

(early centres of the worsted industry), and numerous other towns, such as Sandwich (the port at which many of them landed), Macclesfield, which began making silk buttons, Coventry, which made ribbons, and Canterbury, making fine gold silks, harboured the foreigners and their crafts. During the seventeenth century the development of the knitting frame encouraged the development of silk-hose manufacture at Nottingham and Derby. Then the influx of Huguenots, in and after 1685, brought further skill to Britain. A colony of considerable size was established at Spitalfields, in the east end of London,[1] and small bands of refugees settled in many likely and unlikely towns all over the country. By 1700, the silk industry, centred chiefly at Spitalfields, was one of Britain's most flourishing trades. Commencing in 1713, the Government devoted considerable attention thereto[2] by placing heavy duties, and later total prohibition, upon imported silk goods, and the result was a considerable expansion of the manufacture in various parts of the country, raw silk being obtained from Turkey and the Levant, from Italy, and India. Physical influences in the location of the manufacture were almost non-existent; neither the raw material nor the finished product was bulky, and weaving might take place anywhere. The pre-existing woollen industry and the accidental settling of foreign craftsmen are all the explanation that can be given.[3] The introduction of the silk throwing process into this country from Italy by John Lombe in 1717 at Derby gave a new aspect to the industry. Derby and the Macclesfield area developed numerous mills, and the

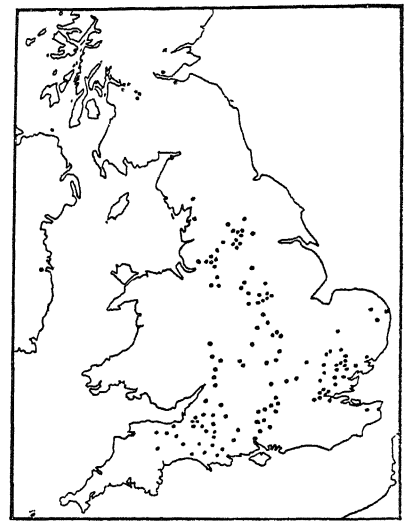

FIG. 230.—Map showing all localities where the silk industry has been carried on in Britain

Notice the concentration in (1) London and the Eastern Counties; (2) the West Country; (3) the Midlands, including the West Pennines, (4) the Lancashire–Yorkshire textile regions and (5) the Scottish Lowlands

[1] Spitalfields already had a wool-weaving industry, carried on mainly by Nonconformists—two very good reasons for the settling of the dissenters there. About 15,000 foreigners settled in London and its eastern suburbs in 1685–1686.

[2] 1713–1765, heavy duties; 1765–1826, total prohibition of manufactured silks; 1826–1860, tariff of 15 per cent. *ad valorem*; 1860, abolition of all duty.

[3] In some cases water, in connection with dyeing, exercised some influence. For a detailed examination of geographical factors, see C. L. Mellowes, "The geographical basis of the West Pennine Silk Industry," *Journ. Textile Inst.*, Oct., 1934, 376–388.

introduction of ribbed hose (cf. p. 523) gave a further fillip to the industry in Derby, where silk was the staple trade by 1800. Norwich reached the height of its prosperity between 1740 and 1760, its black crêpe and "challis" (a fine silk-worsted material) becoming standard materials for women's clothing. Several centres farther south, *e.g.* Braintree and Bishop's Stortford, began silk throwing, and Spitalfields had 30,000 workers in 1800. Numerous West Country towns, already important for wool, also took up the trade, for example, Malmesbury, Sherborne, Taunton. Dublin had a flourishing silk industry in the late eighteenth century developed by French immigrants, and at Paisley, where silk gauzes began to be made about 1760, no less than 10,000 people were employed in the 'eighties, before the coming of cotton almost ruined the trade.

The greatest period of the silk industry was the first half of the nineteenth century. The Spitalfields area declined rapidly after the development of machinery, owing to its high labour costs compared with the provinces, but a considerable expansion took place in the Macclesfield area, and many more West Country towns took up throwing and weaving. The introduction of machinery for spinning "waste" silk (short fibres) brought two new areas into the industry, the West Riding, where spun silk began to be employed for admixture with alpaca and fine worsteds, and for making plushes and upholstery cloths, and South Lancashire, where cotton machinery was quickly adapted for silk—and still further increased the importance of the Cheshire centres.

A sudden blow was given to a large part of the silk industry in 1860 by the abolition of the duties, thus allowing cheap French silks to flood the English market. The 130,000 employees of 1851 were reduced to 39,000 in 1901, and at such important centres as Derby and Coventry, and in many West Country towns, the industry practically ceased to exist.

At the present time the principal silk-manufacturing region lies in south-east Cheshire and north-west Staffordshire, at Macclesfield, Leek, and Congleton. The water supply of the Pennine streams has been of considerable importance here in enabling fine dyeing and finishing to be done. A silk province of less rank is Yorkshire. Brighouse is the chief seat of silk spinning in the country, and numerous other wool-textile towns (*e.g.* Bradford, possessing the largest mills in Britain) have silk mills, producing plushes, upholstery cloths, and mixed fabrics. The rest of the silk industry comprises the scattered remnants of that which is indicated in Fig. 223. Norwich, Braintree, Sudbury, and Haverhill in East Anglia, Tiverton and Taunton in the west country, Nottingham and Derby in the knitwear province, Manchester, Glasgow, and Dublin (famed for poplins) are perhaps the most important. The following tables illustrate the silk trade.

IMPORTS OF RAW AND SEMI-MANUFACTURED SILK

(Thousand lb)

Variety	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
Raw Silk	970	717	1,290	1,875	4,288	1,408	1,780
Knubs and Waste	6,272	3,024	2,789[1]	1,537	2,544	243	260
Noils	1,120	183				—	—
Thrown Silk	479	45	798[2]	952	162	4	11
Spun Silk Yarn	575	682				93	36

[1] 1926–1935. "Cocoons and Waste of all kinds."
[2] 1926–1935. "Silk Yarn."

IMPORT OF RAW SILK BY COUNTRIES

(Thousand lb.)

Country	1913	Average 1921–25	Average 1926–30	1931	1935	1949	1950
China	508	312	369	320	285	63	41
Japan	102	104	526	1,208	3,549	1,222	1,414
Italy	58	177	206	205	161	1,214	381
France	194	13	60	40	60	—	—

EXPORT OF SILK AND MANUFACTURES THEREOF BY COUNTRIES, 1913–1935

(Thousands of £'s)

Country	1913	Average 1921–25	Average 1926–30	1931	1935
U.S.A.	413	223	247	59	91
Argentina	86	102	59	32	104
India	89	67	72	43	82
Australia	147	335	348	202	120
New Zealand	29	83	60	41	31
Canada	204	174	120	42	44
France	322	244	170	106	117
Germany	241	18	131	56	92
Other countries	627	883	895	456	441
Total	2,158	2,129	2,102	1,037	1,142

EXPORT OF SILK AND ARTIFICIAL SILK MANUFACTURES BY COUNTRIES, 1949–1950

(Thousands of £'s)

Country	1949	1950
U.S.A.	440	799
India	1,734	878
Pakistan	540	503
Australia	139	179
New Zealand	3,903[1]	5,677[1]
Canada	1,394[1]	838[1]
France	67	102
Total	41,903	50,143
(Artificial Silk)	34,055	39,413

[1] Artificial Silk only

Artificial Fibres[1]

The use of "artificial" fibres in the textile industry is a relatively recent development, for although much of the experimental work was accomplished between 1850 and 1900, and although the first British "artificial silk" factory was set up by Messrs. Courtauld's (the Braintree silk firm) at Coventry in 1906, it is really only since the First World War that rayon has become a textile material of serious importance, whilst the rise of the nylon industry can be dated from the Second World War. Fundamentally, both rayon and nylon production are chemical industries, and as such will be referred to again in Chapter XXII; rayon may be described as "regenerated" fibre, derived from organic substances—wood pulp and cotton linters —whilst nylon is "synthetic," its raw materials being chemicals derived from coal or petroleum.

Rayon.—Rayon production requires, in addition to the wood pulp and cotton linters, certain chemicals and vast quantities of water, amounting to several million gallons a day, with suitable means of effluent disposal. It is impossible to generalise about the reasons for the present location of works; in detail there are different factors in almost every case. Some of the works merely produce fibre, others are textile factories as well. The biggest factory is that of Courtauld's at Greenfield, on the Flintshire coast; the *site* of this works has been described as "largely fortuitous" (Moisley, *op. cit.* p. 86) but the *location*, like that of the works at Flint, at Liverpool, and at Preston is intelligible enough, in relation to the Mersey ports and chemical industries and the textile area of south Lancashire. There are several smaller works in Lancashire, and other large, though

[1] H. A. Moisley, "Rayon Industry in Great Britain," *Geography*, XXXIV, 1949 78–89.

more isolated works exist at Spondon, near Derby (originally a cellulose factory), at Coventry, where the silk industry is of long standing, and at Wolverhampton (adjacent to the Black Country where flourishing chemical industries exist). More recently a large plant has been established in one of the "Development Areas"—at Wrexham.

The products of the rayon factories may take one of two forms: (i) continuous filament yarn, comprising twenty to one hundred filaments, produced by extrusion, twisted together; (ii) staple fibre, consisting of similar filaments cut into short lengths corresponding to long-staple cotton or short-staple wool. Both continuous yarn and staple fibre (after spinning) can be woven on ordinary textile machinery just like, and often mixed with, cotton or wool.

Rayon-using has thus attached itself to the pre-existing textile industries, in south Lancashire (Manchester and the "weaving towns" especially), in West Yorkshire (especially the "worsted" district), in the silk province of Macclesfield–Leek, in the south-east Midlands (Nottingham, Leicester, and Long Eaton), and in west Scotland (Glasgow–Paisley); some of the few remaining East Anglian centres of the textile trades have taken up rayon (*e.g.* Braintree, Sudbury), and there are several factories in the London area and in Northern Ireland.

The phenomenal rise of the rayon industry is indicated statistically in the accompanying tables; although for many official purposes silk and artificial silk are lumped together it is easy to see that a great and rapidly expanding industry has come into being, with a flourishing export trade.

Nylon.—The nylon industry is much more recent even than rayon. There was some production for special purposes during the Second World War, but the first large factory, near Pontypool in South Wales, began production only in 1949. Again there is the dual character of the industry, chemical and textile, and this new enterprise has been sponsored by Courtauld's and Imperial Chemical Industries, who joined forces to form British Nylon Spinners, Ltd. The raw material being coal, and South Wales being a "Development Area," Pontypool was chosen—off the coalfield but thereby having a more open situation, with room for expansion and no danger from mining subsidence.

Terylene.—The latest addition to the range of artificial fibres is terylene, which has great strength, crease-resistance and wearing properties, and is suitable especially for underclothing and socks, and also for conveyor-belts and ropes. It will be made at the vast new chemical works at Wilton, near Middlesbrough (cf. p. 543); its raw materials are para-xylene and ethylene glycol, both petroleum derivatives, together with methanol and nitric acid.

EXPORT OF ARTIFICIAL SILK MANUFACTURES

(Thousands of £'s)

Variety	1934	1936	1949	1950
Yarn (including doubled yarn) . . .	1,011	676	6,340	9,038
Tissues, wholly of artificial silk . .	1,022	1,425	27,535	31,591[1]
Tissues, mixtures of artificial silk and other fibres (except silk)	2,190	1,766	3,444	3,382
Others (lace, etc.)	537	581	—	—
Total	4,760	4,448	34,055	39,413

VALUE OF OUTPUT OF MINOR TEXTILES

(Thousands of £'s)

Variety	1907	1912	1924	1930	1948
Linen	19,750	21,027	32,717	18,132	4,280
Jute	9,813	10,211	14,230	8,965	6,366
Silk	2,291	3,663[1]	4,930	4,203	} 44,933[2]
Artificial Silk . .	—	—	1,976	4,482	

[1] Approximate.
[2] Silk, nylon, and artificial silk.

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CHAPTER XXII

THE CHEMICAL INDUSTRIES [1]

LORD MCGOWAN, the Chairman of Imperial Chemical Industries, Ltd., has aptly described the chemical industry as the most polygamous of all industries. There are few manufacturing industries to-day which can dispense with the services of the chemist, and the vast field covered by the chemical industry of to-day is the natural result of co-operation between the chemist and his fellow scientists, or between the chemist and the engineer and manufacturer. Quite truthfully the chemical industry has become the foundation on which not only British industry as a whole but also modern world-industry is erected. Not only has chemistry become the servant of the older industries but in many cases the powerful rival, and in some cases the master. The synthetic products produced by the combined ingenuity of engineer and chemist not only serve to meet demands created by a high standard of living, but come definitely into competition with substances of natural origin, or even the earlier products of the chemists themselves. Thus, synthetic nitrates are more than adequate competitors for the favours of the agriculturalist requiring nitrates for fertilising. The quantity of artificial silk and chemical fibres used in the world now exceeds the quantity of natural silk. The last two or three decades have seen chromium plating replace nickel plating just as nickel plated goods replaced brass and bronze of earlier periods. Similarly, plastics have largely replaced metals —especially brass—and also wood, glass, leather and textiles for many purposes. In the near future oil produced by the hydrogeneration of coal may possibly replace natural mineral oil when supplies of the latter begin to diminish.

The Heavy Chemical Industry

The heavy chemical industry is in many respects the chemical industry proper, and embraces the manufacture of those commodities which are required in large quantity and have a variety of uses. The birth of the whole chemical industry took place little more than 200 years ago, and indeed, at the close of the eighteenth century there was scarcely a chemical industry in this or any other country —apart from the manufacture of gunpowder, a few acids in small

[1] The authors are indebted to Prof. H. D. Springall and Dr. P. H. Plesch for advice on the revision of this Chapter.

quantities, and a few drugs.[1] One of the first chemicals produced in quantity was sulphuric acid, manufactured in England as early as 1720. The discovery of the value of chlorine as a bleaching agent in 1785 opened up a new avenue of manufacture, and towards the close of the eighteenth century the discovery of bleaching powder, or chloride of lime, by Charles Tennant, led in 1797 to the foundation of the chemical works at St. Rollox in Glasgow. Within a few years the manufacture of bleaching powder by passing chlorine over dried powdered lime was an important industry in many parts of the country. In 1790 the French Government awarded a prize to Nicholas Leblanc for a method of making soda, since France, owing to wars, had found it difficult to obtain a constant supply of this commodity. His method consisted of treating common salt with sulphuric acid, thus making sodium sulphate and liberating hydrochloric acid gas, then roasting the sodium sulphate with limestone and charcoal or coal and obtaining in this way sodium carbonate and calcium sulphide. The growth of the Leblanc soda process in this country was slow, but it is not difficult to see that salt is the primary raw material in the manufacture of soda and alkalis. Thus, the manufacture of soda, sooner or later, gravitated to the one great salt field of this country then known—the Cheshire salt field. It was not long before the factory of a soda manufacturer tended to become larger and more complicated. He not only made soda, using common salt, sulphuric acid, and other raw materials, but he started to make his own sulphuric acid by burning sulphur or pyrites. He produced large quantities of hydrochloric acid which at first were allowed to escape into the atmosphere with terrible results on areas around the chemical works. So it is easy to see how he became a manufacturer of acids, more especially of nitric acid, which is required in the manufacture of sulphuric. Then followed the various salts of sodium, copper, and iron. It was again a common development to use the chlorine recovered to make bleaching powder, and more and more efforts were made to utilise what had at first been waste products. Thus, at first, for every ton of soda made nearly two tons of alkaline waste were produced, an evil-smelling mass containing practically all the sulphur from the sulphuric acid used; and, although by a process introduced in 1861 a third of the sulphur was recovered, it was not until 1882 that waste was really eliminated. The elimination of waste was more or less forced on the chemical manufacturers by the Alkali Act of 1863, which provided for close inspection, and for heavy penalties against emitting obnoxious fumes into the atmosphere. By 1890 the British heavy chemical industry was thus in the hands of forty or fifty firms whose works were situated principally on the salt-field

[1] On the history of the chemical industry, see A. and N. Clow, *The Chemical Revolution*, London, Batchworth Press, 1952.

of Cheshire and the neighbouring parts of the mid-Mersey region of Lancashire. As soda manufacturers they were suffering from the severe competition of what is known as the ammonia-soda process for the manufacture of soda. The chemistry of the process involved in the mixing of salt, ammonia, carbon dioxide, and water to form bicarbonate of soda and ammonium chloride is very simple, but it was not until 1856–1866 that the Solvays of Belgium were successful in producing soda in quantity by this process. It was they who, in 1873, granted a licence to Brunner, Mond & Co., a combination of Brunner the administrator and Mond the energetic young chemist, to manufacture in Great Britain. In 1890 the British heavy chemical firms were forced into combination and formed the United Alkali Co. of Liverpool. Although the object of the combination was to facilitate, by lowering costs, the continuance of the manufacture of soda by the Leblanc process, they were forced in turn to take up the ammonia-soda process. Some idea of the progress may be judged by saying that in 1863 the world's production of soda was 300,000 tons and the price about £13 per ton. In 1902 out of an annual production of 1,800,000 tons, 1,650,000 were made by the Solvay process, and the selling price was only about £4 per ton.

To go back somewhat, the close connection between the heavy chemical industry and many other industries was apparent early. With the Industrial Revolution the growth of the textile industry meant an increase in demand for acids, alkalis, soaps, and chemicals of all kinds. The increased use of soap all over the world meant increased demand for the alkalis used in its manufacture. Thus there was a dual marriage of the chemical and the textile industries, the chemical and the soap-making industries. The ramifications of the chemical industry became increasingly apparent towards the latter half of the nineteenth century. The year 1887 saw the patenting of the famous McIver-Forrest Cyanide process for extracting gold and silver from refractory ores and from "tailings" —a process which has revolutionised gold mining, for there are few mines existing to-day which can be operated properly without a cyanide annexe to the mill. This has meant the extensive manufacture of cyanide in this country. Then the early experiments of Mr. J. B. (later Sir John) Lawes, who succeeded to the Rothamsted estate in Hertfordshire, led to the appreciation of various artificial manures, and in 1843 Mr. Lawes established large works in the neighbourhood of London for the manufacture of superphosphate of lime.

The outbreak of war in 1914 found the chemical manufacturers of this country quite unprepared. There were government factories well equipped for the manufacture of explosives, but they were only on a small scale. Firms, such as Messrs. Nobel, had up-to-date works, but again on a small scale. Apart from some of the larger

firms such as Brunner, Mond & Co. the smaller alkali manufacturers had works which were far from up-to-date. At the beginning of the war most of our shells were filled with picric acid as an explosive, for T.N.T. or trinitrotoluene had only just been adopted. The first government factory for its manufacture was not commenced until February, 1915, although exactly three months later the first ton of T.N.T. was produced and packed for delivery and the factory was very soon producing to capacity. Of necessity the explosive firms in particular and the chemical firms in general had during the war period to work together and to pool their knowledge. The way was thus paved for the formation of the combine in November, 1918,

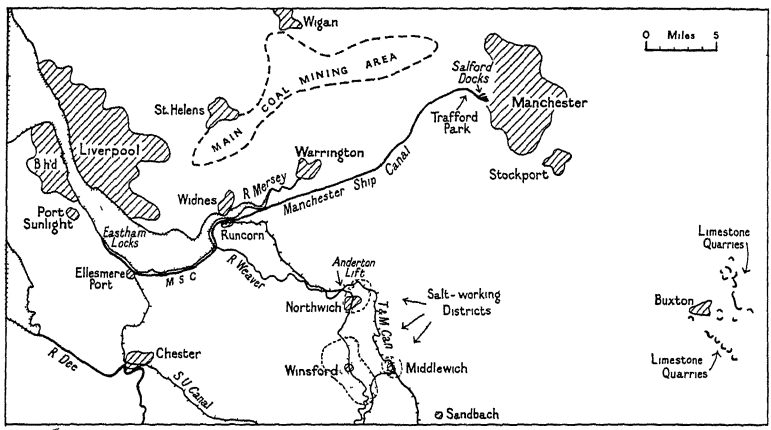

FIG. 231.—The mid-Mersey chemical towns, in relation to sources of salt, coal, and limestone

of Explosive Trades, Ltd., afterwards known as Nobel Industries, Ltd., the chief establishment of which was at Ardeer on the Ayrshire coast. There thus came to be four great firms concerned with the chemical industries of this country: Brunner, Mond & Co., Nobel Industries, Ltd., the United Alkali Co., and British Dyestuffs Corporation, Ltd. The amalgamation of these came naturally in 1926 with the formation of Imperial Chemical Industries, Ltd., the British combine with a capital of £65,000,000 sterling.

Geographical Distribution of Chemical Industry

Geographical factors in the distribution of the various branches of the chemical industry are fairly obvious, and many of the early locational influences—including sources of salt and fuel, and inland water transport—continue to be important. The greatest concentration of the industry is in the mid-Mersey region and the Cheshire saltfield.[1] Here on the saltfield is the Headquarters of the I.C.I.

[1] See *A Scientific Survey of Merseyside*, pp. 251–64. British Association, 1953.

Alkali Division, at Winnington, Northwich (the former Brunner, Mond Works, established in 1873 alongside the River Weaver). Some 50 per cent. of the insured population of Northwich is employed in the chemical industry. Also on the saltfield are Winsford, where 45 per cent. of the insured population work in the salt industry (again along the River Weaver), Middlewich, and Sandbach. On the banks of the Mersey, and served also by the Manchester Ship Canal and by several older but still navigable canals, are Widnes, Runcorn, and Warrington, lying mid-way between the saltfield [1] and the Lancashire coalfield, and with waterway connection to the textile centre of Manchester and to the port of Liverpool (source of imported fats, vegetable oils, pyrites, and other raw materials). In Widnes and Runcorn about 40 per cent. of the insured population are employed in chemical industries; Warrington is more diversified, and its 6 per cent. employed in chemicals are mainly connected with soap (though several of its other trades are closely linked with the chemical industries—e.g. leather tanning, paper, and cardboard). Close to these towns is St. Helens, centre of the glass industry (see below p. 548).

Of the other areas, the most important is Teesmouth, where the salt and anhydrite deposits in the Keuper Marl were responsible for the development between the two world wars of the vast I.C.I. plant at Billingham, which covers 1,000 acres, and to which was added, after the second war, an even larger works at Wilton, to the east of Middlesbrough, and connected to Billingham by pipe-lines under the Tees.

At Fleetwood, the chemical industry arose from the combination of local brine-pumping and port facilities. On the Tyne, salt-panning was an ancient practice; the modern chemical trades are linked with the availability of fuel and of waste gases from coke ovens and of course with the port facilities.

The association of the West Midlands with the chemical industries arises largely from the metallurgical trades and glass manufacture—at Oldbury and Smethwick respectively. Important outlying centres of the chemical industries are Avonmouth (Imperial Smelting Corporation) and Wrexham, where the great Monsanto works has grown up (in the North Wales Coalfield "Development Area") since the Second World War.

The explosives industry is often located—for obvious reasons—in relatively remote areas where wide expanses of poor land are available. The best example, particularly since it did not, like so many others, owe its origin to either of the two world wars, is the vast works at Ardeer, on the Ayrshire coast, established in 1873 and later incorporated in the Nobel group. A more recent example is near Burry Port in South Wales.

[1] Some of the works at Widnes and Runcorn use brine pumped by pipe-line from Northwich.

The following table gives the numbers employed in various branches of the chemical industry at the Census of Production, 1948.

EMPLOYMENT IN CHEMICAL INDUSTRIES, 1948
(Thousands)

Industry	Employment	Chief Regions [1]
General Chemicals . . .	100	N.W. 31; N. 21; London and S.E. 15.
Explosives and fireworks .	25	Scot. 9; Wales 4; N.W. 4.
Soap, candles, and glycerine	21	N.W. 11; London and S.E. 3.
Dyes and dyestuffs . . .	17	Yorks. 8.
Drugs and pharmaceuticals	47	London and S E. 19; N. Mid. 7; N.W. 7.
Toilet preps. and perfumery	9	London and S.E. 7.
Fertilisers and insecticides	15	Scot. 3; London and S.E. 2; Yorks, 2; N. 2.
Paint and varnish . . .	33	London and S.E. 12; N.W. 5; Yorks. 3.

[1] Ministry of Labour Regions, see footnote to table on p. 427.

The Metallurgical Industry

There is a close association between non-ferrous metal smelting and refining and the chemical industries, for chemicals are used in metal processing and numerous chemical by-products are obtained. Thus it was Mond, of Brunner, Mond & Company, who discovered with a collaborator a process for the extraction of pure nickel and floated the Mond Nickel Co. whose large works are at Clydach, near Swansea (cf. p. 454). The chemical by-products of lead and zinc smelting have already been referred to (pp. 448, 449). More recently the development of the use of the rarer metals in the electrical industries, in alloy steel making and for lightweight alloys has widened the range of contact between chemical and metallurgical industries, and new developments are frequent. In fact the processing of these metals is for the most part done by the chemical industry and not by firms whose main interest is in metals. Molybdenum, zirconium, tantalum, tungsten, and titanium are examples. Tantalum has found a use in the rayon industry: it is used for the spinnerettes in the viscose process. Titanium, being completely non-corrosive, whilst of high strength and low density, is being developed for use in ships and aircraft. The oxides of some of these rare metals are used in catalytic reactions, e.g. in the production of synthetic ammonia and in petroleum cracking.

The Gas and Coke Industries

Although the distillation of coal on a large scale for the production of gas seems to have been practised well before the end of the eighteenth century, and in Germany various experimenters had

known the importance of coal gas as an illuminant, it was left to two men, Murdock of Ayrshire, and Lebonne a Frenchman, independently to develop the commercial production of coal gas for lighting purposes. Murdock lighted a large mill at Manchester in 1805 with gas, and in the meantime Winzau, a German, who had failed to arouse enthusiasm in his own country, succeeded in doing so in London, and obtained sufficient money to carry out the lighting of the greater part of Pall Mall (January, 1807), the first public thoroughfare in the world to be illuminated by gas. His company received a royal charter in 1812, and later became the Gas, Light, and Coke Company. The gas industry made steady progress. The purification of the gas is now so good that further improvement cannot be regarded as really necessary. But up to 1890 the lighting properties of the gas depended upon those vapours it contained which burnt with a luminous flame; but later it was discovered that it was better and cheaper to remove from the coal gas these luminous gases and to rely on the heating properties of the gas to raise metallic oxides on gas mantles to so high a temperature that they became incandescent. So the problem became to maintain the heating properties of the gas at a maximum and to recover from the gas the vapours which had previously given luminosity to the flame. Gas is produced by heating bituminous coal in closed vessels called retorts. The volatile gas is removed and the porous coke, which remains, contains as high a proportion of carbon as anthracite and is used for similar purposes, especially for central heating. Gas, by reason of its nature, must almost of necessity be produced near centres of consumption, and the main geographical factor arising in the location of gasworks is the ease of import of the bulky raw material, coal. Hence the larger works, for example in London, tend to be riverside works. In the smaller towns the gasworks are almost invariably situated conveniently near the railway. A by-product of gas production is coke for domestic and industrial use. The production of metallurgical coke is a separate industry (see p. 323).

The Dyestuff Industry

The aniline-dye industry originated in England in 1856 when a brilliant young chemist, W. H. (later Sir William) Perkin, discovered that mauve could be manufactured from coal tar. Perkin and a band of young German chemists working in this country developed the industry, and for some years it flourished. But the nation did not appreciate the brilliant discoveries, and the whole industry practically disappeared from Britain and was built up on a commercial scale in Germany. There it became one of enormous importance, and the artificial dyes made from coal tar practically eliminated from the world's markets natural dyes such as indigo.

The outbreak of war in 1914 found this country almost totally unprepared so far as a supply of dyestuffs was concerned. But two firms were still in existence and they were galvanised into immediate action; for it has been truthfully said that without dyestuffs an army cannot be uniformly clothed, and an army without a uniform is but a rabble. A new firm started work at Manchester and Scottish Dyes, Ltd., at Grangemouth in Scotland. Amazing progress was made, so that by 1918 it was not surprising to find an amalgamation of interests under the name of British Dyestuffs Corporation, Ltd., which later purchased a controlling interest in Scottish Dyes. In turn, as part of the chemical industry, this became an essential constituent of Imperial Chemical Industries, Ltd., and British dyestuffs can claim to be unrivalled in the world. About 80 per cent. of dyes used in Britain are now home-produced, and a considerable proportion of the output emanates from the textile regions of Lancashire and Yorkshire, where Manchester and Huddersfield are the principal centres.

Intimately linked with the dyestuffs industry, since similar complicated organic molecular structures are involved, and similar raw materials, are the manufactures of pharmaceuticals, insecticides, and other agricultural chemicals, rubber additives, and plasticisers for plastics.

Artificial Fibres [1]

There is an unexpectedly close connection between explosives and artificial silk, both being closely connected with cellulose, which is the main constituent of dry vegetable matter, and thus forms the bulk of wood, cotton, linen, and many other vegetable products. Thus, if cotton rags are treated with caustic soda, washed, bleached, and dried the production of cellulose is the result. If the cellulose is dissolved in a mixture of sulphuric and nitric acid nitro-celluloses are formed, which are in general highly inflammable or explosive substances. Gun cotton is a nitro-cellulose, and cordite and other explosives are closely associated. On the other hand harmless solids can be formed from similar bases. Examples are xylonite—a mixture of cellulose-nitrate and camphor with a little castor oil, and celluloid which is a mixture of cellulose-nitrate and camphor. The principle of making artificial silk is to dissolve cellulose-nitrate in a suitable organic solvent, and then to squeeze the liquid through very tiny holes so as to make a thread which, when it is dry, is as fine or almost as fine as the silken thread naturally spun by the silkworm. As early as 1885 a few articles were produced under the description of artificial silk; but the real progress of the industry is very largely post-1918. In the production of viscose silk, wood-pulp or some other material containing cellulose is treated with caustic

[1] See also p. 536.

soda and then with carbon bisulphide; a yellow viscous liquid being obtained which when put into a suitable precipitating bath yields tough fibres. A further process is used to remove the sulphur from such fibres. Another variety of artificial silk is acetate silk, produced by treating cellulose with acetic acid (derived from petroleum refining). Another artificial fibre is alginate yarn, a soluble yarn of great value in the production of certain types of textile fabrics, since it disappears when the fabric is washed; it is made from seaweed. The recent development of "nylon" and "terylene" is intimately bound up with the great post-war expansion of the petrochemicals industry (cf. p. 566), for these new fibres are largely made from petroleum derivatives.

The Soap Industry

Although the making of soap is essentially a chemical industry, soap making long antedates the development of the chemical industry properly speaking. The art of boiling together oils and fats with an alkali (which was usually obtained by burning seaweed, thus giving an impure alkali containing both soda and potash), and then adding common salt which throws out the soap as a curd that can be cut into bars, tablets, and the like was practised long ago. But clearly the modern connection with the chemical industry is the large requirement of alkali and salt. In the early days almost any fat or oil was used, and it is not surprising therefore to find the early soap-boiling works scattered in different places throughout the country. The great business of Lever Brothers was built up very largely on the utilisation of vegetable oils instead of animal fats as the basis for soap making. The greatest of all the centres created by the company, Port Sunlight, was initiated in 1888. W. H. Lever selected this site because "it was a rural area where ample acreage could be secured adjacent to both rail and water transport with reasonable facilities for obtaining the necessary supply of labour." Incidentally the area chosen is conveniently situated to the alkali-manufacturing centres of the Mersey. The Lever interests gradually absorbed many of the soap-making companies; there was close connection also with those who were using oil for other purposes, such as the British Oil & Cake Mills Ltd., and finally, in 1929, came the merging of interests with the Margarine Union, which had been using vegetable oil for the manufacture of margarine. The whole great combine is known as Unilever Limited, which manufactures in fifty countries and employs more than a quarter of a million people.

Although Port Sunlight dominates the industry, there are other centres in the North-Western Region, notably Warrington; outside Merseyside, the port area of London, and several centres in Scotland

such as Renfrew, Paisley, and Grangemouth are concerned with soap manufacture.

The soap industry is turning in part to new products—synthetic detergents or "syndets," which are now flooding the market under numerous proprietary names. These detergents—which started by being soap substitutes and have turned out to be in fact very much better than soap for many purposes, particularly with hard water—are made for the most part from oil refinery waste products, and both the soap firms and the petrochemical interests are involved.

Glass

The manufacture of glass is essentially a chemical process. All types of glass are made by heating in a furnace, silica (which is usually obtained in the form of sand) with soda and lime and the oxides of other metals such as magnesium, aluminium, boron or lead, according to the type of glass required—e.g. a large proportion of borax is used for "pyrex" heat-resisting glass. The mixtures are very complex; ordinary bottle glass contains no less than twelve chemical elements. Plate glass is rolled in continuous sheets while soft; glass tubing is drawn out; glass bottles are cast in moulds or are blown. The main requirements of the glass industry are thus a suitable supply of fuel, sand, and chemicals, chiefly soda, lime, magnesia, and borax from the heavy chemical industry. For the finer types of glass, including colourless milk bottles, the purest white sand, free from coloured impurities, must be used. Such sand comes from the superficial Shirdley Hill Sands of South-West Lancashire and from occasional pockets in the Lower Greensand formation—as at King's Lynn, Leighton Buzzard, and Redhill—or is imported from Belgium or elsewhere. A new source of high-quality sand was discovered during the Second World War at Lochaline in western Scotland. For coloured bottles, less-pure raw material is needed, and several other geological formations, as well as those named above, contribute supplies.

The glass industry in 1948 gave employment to over 60,000 people, of whom 24,000 were concerned with bottle-making. The London area, by reason of its huge market for milk and beer bottles, and easy access to Lower Greensand and imported sand supplies, has a very large bottle-making industry, and other centres are Doncaster and St. Helens. The latter town is also the chief in the country for glass-making other than bottles. The geographical influences here were simple—Shirdley Hill sands and coal almost on the spot and the great mid-Mersey chemical industry only a few miles away. Interesting, if less obvious, locations are Stourbridge, on the edge of the Black Country (where the glass industry was started by foreign refugees several hundred years ago), Smethwick, chief British

centre for the making of lighthouse lanterns, and Sunderland, home of "pyrex" glass.

Plastics

The plastics industry is essentially a product of the last two or three decades; of small importance before about 1928, it was greatly stimulated by the rapid growth of the electrical and radio industries, and great advances were made during the Second World War. The output increased more than four-fold during the decade 1938–1948.

The plastics industry, like that of artificial fibres, consists of two parts, the actual production of the synthetic resins and moulding powders, which is very definitely a chemical industry, and the manipulation of the materials, which are now used in a great variety of industries, electrical, radio, furniture and household fittings, aircraft, boat-building, paint, plastic crockery, glass substitutes, brushes, raincoats and table-covers, and an ever-increasing range of miscellaneous manufactures. But there is a much closer link between the two parts than in the case of the textile fibres. The basic chemicals, which are derived from salt, coal, oil, nitrogen, etc., are married together by the process known as polymerisation into plastic materials. There are two major types: (i) thermo-setting plastics, which harden by chemical action brought about by heating and cannot subsequently be softened again; they are moulded by compression; (ii) thermoplastics, which are moulded by injection or are produced in flexible sheets, rods, or tubes, in a wide range of colours. The thermo-setting plastics are based on phenol (derived from coal tar), formaldehyde (from carbon monoxide and hydrogen) and urea (from ammonia and carbon dioxide); they are used for such things as door knobs, laminated sheets, plastic crockery, electrical insulators, table-tops, etc., in paint manufacture and as a bonding material in plywood and furniture. The thermoplastics are of two kinds, those derived from cellulose, the manufacture of which depends on imported cotton linters, and the "synthetic" materials, derived mainly from coal and petroleum but using also salt and limestone. The synthetic plastics are of quite recent development, mainly during and since the Second World War, and include polythene (based on ethylene derived from oil cracking), "perspex" or glass-substitute (derived from acetone), polyvinylchloride ("P.V.C."—based on carbide and chlorine), much in use for raincoats, curtains, table-covers, handbags, wall and floor coverings, etc., nylon (from benzene), used as a textile and for brush-bristles, rope, racket strings, and as sheet and film for packaging, and polystyrene (from benzene and ethylene), used for toys, table-ware, toilet articles, radio parts, etc.

The wide variety of raw materials, both home-produced (coal

derivatives, salt, limestone) and imported (petroleum, refined at the ports of entry—see p. 567—carbide, cotton linters, wood pulp, resins, etc.) and the equally wide variety of products and markets result in a widespread distribution of the industry. Moreover, the industry has been taken up by many firms previously engaged in other or allied trades, and so it is not easy to generalise about location factors. But since there is little wastage of raw materials during manufacture, labour supply and markets rather than raw materials tend to be of most significance—hence the importance of the Greater London and Birmingham areas, for example—whilst the "light" and largely "footloose" character of the manipulation side of the industry has made it a suitable one for setting up in the Development Areas. The list of localities contains more unexpected and not readily explicable places than is the case with almost any other manufacturing industry. The I.C.I. Works at Northwich produces most of the known varieties, and its new plant at Wilton, near Middlesbrough (see p. 543) will produce "terylene"; outside the main "chemical" areas the chief I.C.I. establishment is at Welwyn Garden City.

Other Chemical Industries

There are many other chemical industries which deserve more than passing mention. The most important is the *pharmaceuticals* branch, which in fact can be divided into six quite distinct subdivisions—(i) medical fine chemicals (e.g. aspirin), (ii) antibiotics (e.g. penicillin)—largely a recent offshoot from brewing and distilling, (iii) potent active principles from vegetable and animal sources (e.g. from opium and from liver), (iv) vaccines and sera, (v) "galenicals" (extracts, syrups, ointments), (vi) compounded and packaged preparations. This is an industry which has expanded enormously during the last few decades; indeed probably three-quarters of the drugs and medicines now on the market were unknown twenty years ago. It is also the largest employer of labour —much of it highly skilled and much of it female—of all the chemical industries outside the general heavy chemical group. A large proportion of the industry is in the Metropolitan area—with important establishments in the newer industrial localities such as Dagenham and Welwyn Garden City; in the provinces the Liverpool and Manchester areas are important and, of course, Nottingham, the home of Boots.

Fertilisers, together with insecticides and sheep-dips, make another important branch. Dependent partly on imported raw materials (phosphates) and partly on home-produced chemicals (e.g. sulphate of ammonia), and having a widespread agricultural market, this industry is fairly well scattered, with an emphasis on port locations and centres (e.g. Ely) within the main agricultural areas. It is also

increasingly bound up with petrochemicals, and some oil refining concerns are now in the business.

Paint and varnish manufacture, depending on pigments, solvents, oils, and resins, is a large employer of labour in several of the major industrial districts, particularly Greater London, South Lancashire, and the West Midlands; in Glasgow and on Tyneside it is clearly linked with the ship-building industry. It is sometimes also allied to the manufacture of edible oils and of oilskin garments, and to an increasing extent it is drawing on the products of the plastic industry. Another closely connected trade is that of *oil-cloth* and *linoleum* manufacture. Oxidised linseed oil and cork are mixed with gum or resin and with pigments and pressed out on a rough canvas body (made from jute) between steam-heated rollers. Kirkcaldy (Fifeshire) has remained the main seat of manufacture in Britain, with an offshoot at Dundee; the link with the jute industry is clear (cf. p. 532).

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A Scientific Survey of Merseyside, pp. 251–264. British Association, 1953. There is a great dearth of geographical literature on the chemical industry, which presents many interesting varieties of industrial location.

CHAPTER XXIII

MISCELLANEOUS MANUFACTURES

IN the preceding chapters we have dealt in turn with the major industries of Britain. It is true that we still have some miscellaneous manufacturing industries to consider but, even allowing for these, there remains the remarkable fact that well over half the population of these islands has still to be accounted for. It is worth while to study with some care the tables which follow in that they illustrate the relative importance of the occupations not yet considered.

MISCELLANEOUS MANUFACTURING INDUSTRIES
EMPLOYMENT, 1948 (Thousands)[1]

Industry	Number employed (thousands)	*Chief Regions*[2] (Number employed in thousands)
China and Earthenware	67	Midland (57).
Glass and Glassware	62	N.W. (19), London and S.E. (14), Yorks (10).
Leather and Leather Goods	49	N W. (10), London and S.E. (6), Yorkshire (5).
Boots and Shoes	114	N Midland (59), N.W (12), London and S.E. (9).
Tailoring and Dressmaking	384	London and S.E (94), N.W. (72). Yorkshire (52), N. Midland (27),
Furniture and Upholstery	93	London and S.E. (30).
Paper and Board	66	London and S E. (15), Scotland (15), N.W. (13), S.W. (6).
Printing and Publishing, etc.	190	London and S.E. (65), Scotland (17), N.W. (17), E. (13), Yorkshire (13).
Rubber	89	N.W. (27), Midland (20), London and S.E. (16), Scotland (10).
Building and Contracting	1,505	Greater London (244), Scotland (100), S.E. (97), Lancashire and Cheshire (97).
Electricity Supply	152	London and S.E. (37), N.W. (21).
Tobacco	45	*

[1] Census of Production, 1948.
[2] Ministry of Labour Regions, see footnote to table on p. 427
* Not available, as regions lumped together.

Perhaps the most striking fact emerging from this table is the important, often dominant position occupied by the London area in almost all these miscellaneous industries. The reason is to be found partly in London's premier position as a port for the import of all manner of raw materials, but mainly in the existence within

Area	Total population	Men	Men "gainfully occupied"	Women	Women "gainfully occupied"
England and Wales (1931)	37,886,699	18,075,239	12,112,718 (67 per cent.)	19,811,460	5,065,332 (26 per cent.)
England and Wales (1931)	39,952,377	19,133,010	13,247,333 (69 per cent.)	20,819,367	5,606,043 (27 per cent.)
Scotland (1921)	4,882,497	2,347,642	1,543,177 (66 per cent.)	2,534,855	636,092 (25 per cent.)
Scotland (1931)	4,842,980	2,325,523	1,542,253 (67 per cent.)	2,517,457	659,057 (26 per cent.)

Approximately 87 per cent. of the males *over* 12 *years of age* were occupied and 32 per cent. of the females. This table *excludes* unemployed.

CENSUS OF 1931 (ENGLAND AND WALES)

Industrial Distribution of the Occupied Population

	Males		Females	
	No	Per 1,000 occupied	No.	Per 1,000 occupied
I. Fishing	26,945	2	80	0
II. Agriculture	1,116,573	84	55,683	10
III. Mining and Quarrying	966,210	73	2,561	0
IV–XXI. Manufacturing (including building)	—	323	—	281
XXII. Transport and communication	1,565,846	118	68,899	12
XXIII. Commerce and finance	1,466,587	110	604,833	109
XXIV. Public administration and defence	290,202	22	2,906	1
XXV. Professions	356,726	27	389,359	69
XXVI. Entertainments and sport	91,654	7	22,369	4
XXVII. Personal service	462,935	35	1,926,978	345
XXVIII. Clerks, draughtsmen, typists	795,486	60	579,945	103
	13,247,333	1,000	5,606,043	1,000

These figures may be compared with 1921 when 39 per cent. of the working population were engaged in manufactures.
13 per cent. in wholesale and retail trade, commerce, and finance.
12 per cent. in personal service, including hotels and restaurants.

the conurbation of some ten millions of people, providing both a source of labour and an immense market for all the necessities and luxuries of civilised life. London's industrial structure will be referred to in some detail in Chapter XXVII.

We may begin our examination of these miscellaneous industries with the only one in which London plays little or no part—the pottery industry.

The Ceramic Industries

According to the Census of Production, 1948, no less than 85 per cent. of all the Pottery workers in Great Britain were in the Midlands Region. In fact the concentration is narrower than this and within the Region almost the entire industry is located in the city of Stoke-on-Trent—one of the most remarkable industrial concentrations in the world. The "Five Towns" of Arnold Bennett's novels (there are actually six, but he omitted Fenton) have become so identified with the pottery industry, that they are known all over the world as "The Potteries." The North Staffordshire coalfield (see p. 301) lies in the south-west corner of the Pennine Uplands, drained by several small streams—of which the most important is the Fowlea Brook—which unite to form the upper Trent, and separated by a low and broken ridge from the Cheshire Plain. In early times it was distinctly isolated, and from about the fourteenth century it seems that the local wood and clays, and later the local coals, were used to make coarse earthenware as a side-line to subsistence farming. By the early eighteenth century the village of Burslem had become quite a noted centre, making, amongst other things, butter-pots for sending Uttoxeter butter to London. Old maps show clearly the crofts with their pottery kilns adjacent to the dwelling or to the barn, and the small clay-holes from which the raw material was obtained. Lead and salt for glazing were accessible from the Derbyshire Limestone area and from Cheshire, respectively. The clays came from the Blackband Group at the base of the Upper Coal Measures—which outcropped in Burslem and Hanley—and the long-flame coals from the adjacent upper part of the Middle Coal Measures. Devon and Dorset ball-clays, and south coast flints, were imported by pack-horse for making finer ware, and the construction of turnpike roads led to the growth of the industry in Longton, at the point where the Derby–Newcastle road crossed the main coal and clay outcrops.

Amongst the skilled families of potters in the mid-eighteenth century were the Wedgwoods. Josiah Wedgwood (1730–1795), was a far-sighted business man as well as an expert craftsman. It was he who introduced Cornish china clay into the potteries in the 1760s; he too, who was a leading spirit behind the construction of the Trent and Mersey Canal, opened in 1777, alongside which he

placed his Etruria Works. The Canal, linking the Trent near Derby with the Mersey at Runcorn, and passing through the western ridge of the coalfield in the famous Harecastle tunnel, gave direct water connection between Cornwall and North Staffordshire. But, curiously enough, the potteries did not migrate to its banks; they remained where they were, in the rapidly growing small towns, for between five and twelve tons of coal were needed for every ton of clay, and the collieries were located close to the towns, whilst the canal ran down the Fowlea Brook valley, which follows the Etruria Marl (barren red Upper Coal Measures) outcrop. The early nineteenth century location of the industry has thus remained unchanged to the present day. The vast majority of the potteries are still in the built-up areas of Tunstall, Burslem, Hanley, Fenton, Longton, and Stoke; the only canal-side potteries are at Longport (where the old turnpike road from Burslem to Newcastle crossed the canal) and a few at Stoke. The china section of the industry (as opposed to earthenware) is located almost entirely in Longton, actually the farthest of all the towns from the canal. Only one firm so far—Wedgwoods—has attempted to leave the congested urban area; in 1939 the old Etruria works were abandoned and a completely new factory, with electric firing and rail transport, was established at Barlaston, a few miles south of Stoke. Two other large works outside the urban area are specialists in the production of electrical porcelain; each lies on a canal—one at Stone alongside the Trent and Mersey Canal, the other at Milton, by the Caldon Canal.

But many "potters' millers" are located on the canal banks, where many of the raw materials (china clay, china stone, ball clay, flint, chert, felspar, calcined bones, etc.), still arrive by water and are prepared for the potters. Accompanying the pottery industry are subsidiary industries concerned with the supply of colours and glazes; and Stoke is the headquarters of the British Ceramic Research Association.

China and earthenware are not the only clay industries in the Potteries. The Coal Measures' fireclays are the basis of the manufacture of saggars (the containers in which the china and earthenware are placed for firing in the kilns), and of glazed tiles, sanitary ware and sewage pipes, and of refractory products. The purple mudstones of the Etruria Marl are the basis not only of a flourishing brick industry, but also supply over one-half of all the roofing tile industry in the country. The tile industry, unlike the pottery trades, spreads beyond Stoke-on-Trent into the neighbouring borough and ancient market town of Newcastle-under-Lyme.

The ceramic industries outside the Potteries are located almost entirely on their source of clay supplies. Thus the Dorset and Devonshire potteries are located on the ball-clays of Poole and

Bovey Tracey respectively. Some of the famous china industries of the past—at Worcester, Coalport, and Derby, for example—are now either extinct or of relatively little importance. The sanitary ware industry, based upon Coal Measures' fireclays, is to be found in such places as Swadlincote (south Derbyshire), Halifax, and Barrhead (near Glasgow).

The Supply of Electricity

Until 1926 the systems of supply of electricity in this country were the result of unplanned growth. Local legislation and piecemeal development had resulted in the existence of numerous isolated area supplies with a great variety of generating plant, frequencies, and pressures. Two inevitable consequences followed—a very wide variation in the cost to the consumer of a unit of electricity and a paralysing or stultifying effect on large scale developments. The domestic consumer might have been called upon to pay anything from ½*d.* or even less per unit to 1*s.* per unit—occasionally more. This book was written in the London School of Economics which, owing to rapid growth, came to include buildings adjacent, but supplied with electricity from two sources. Thus, in some rooms the voltage was 100, in others 210; in some it was direct current, in others alternating! The Electricity Supply Act of 1926 provided for the setting up of a Central Electricity Board. Within this national scheme electricity is to be generated only at those stations where generation can be most economically carried out. These "selected stations" remain the property of the municipal corporations or companies who own them, but the national network of transmission lines connecting them is the property of the Central Board. This network of lines for the transmission of energy at high tension (commonly known as the Grid) has rapidly become familiar through the erection of pylons in all parts of the country, and over these lines takes place the "wholesale" transmission of the current to the various local distributing undertakings.

The main location factors[1] involved in the distribution of power stations are (*a*) proximity to the populous area which the station is designed to serve; this is still important, as the map shows, but with the possibility of large-scale transmission of power at high tension over long distances it is less so than formerly; (*b*) the availability of cheap coal, usually of inferior quality; water-transport facilities, inland or coastwise, are of great importance. In addition to these *location* factors, there are two *site* factors of importance, the availability of cooling water, usually many millions of gallons per hour, and cheap land with room for expansion and for railway sidings and ash disposal. Water-front sites will again be important; if adequate

[1] See E. M. Rawstron, "The distribution and location of steam-driven power stations in Great Britain," *Geography*, XXXVI, 1951, 249–262.

river or sea water is not available, large concrete cooling towers will have to be built (Fig. 232), so that the water can be used over and over again.

A glance at the map will show that the primary generating stations fall into six main groups (apart from the Scottish hydro-electric plants which are referred to elsewhere, see p. 102): (i) the London area, where some four-fifths of the power output comes from Thames-side stations; (ii) South Wales and Bristol, largely at coastal or riverine sites; (iii) the Midlands, divided into a western group,

[*Photo S. H. Beaver*

FIG. 232.—Hams Hall power station, near Birmingham

With only the small river Tame, and pumped underground water available, a large battery of cooling towers is necessary

largely peripheral to the main Birmingham-Black Country conurbation (*e.g.* Hams Hall, Stourport, Ironbridge), and an eastern group, mostly located along the river Trent, (*e.g.* the new stations at Drakelow and Staythorpe); (iv) Lancashire and Yorkshire, where river-sites are again important; (v) north-east England—Tyneside and Teesmouth; (vi) central Scotland, notably Clydeside. The output of electric current increased more than ten-fold between 1920 and 1950, and the expansion shows little signs of slowing down.

The Leather Industry

In its distribution the *fur* industry of Britain is almost entirely distinct from the ordinary leather industry. The dressing and preparation of furs is very largely restricted to London where, in the East End, it occupies a large number both of men and women, the

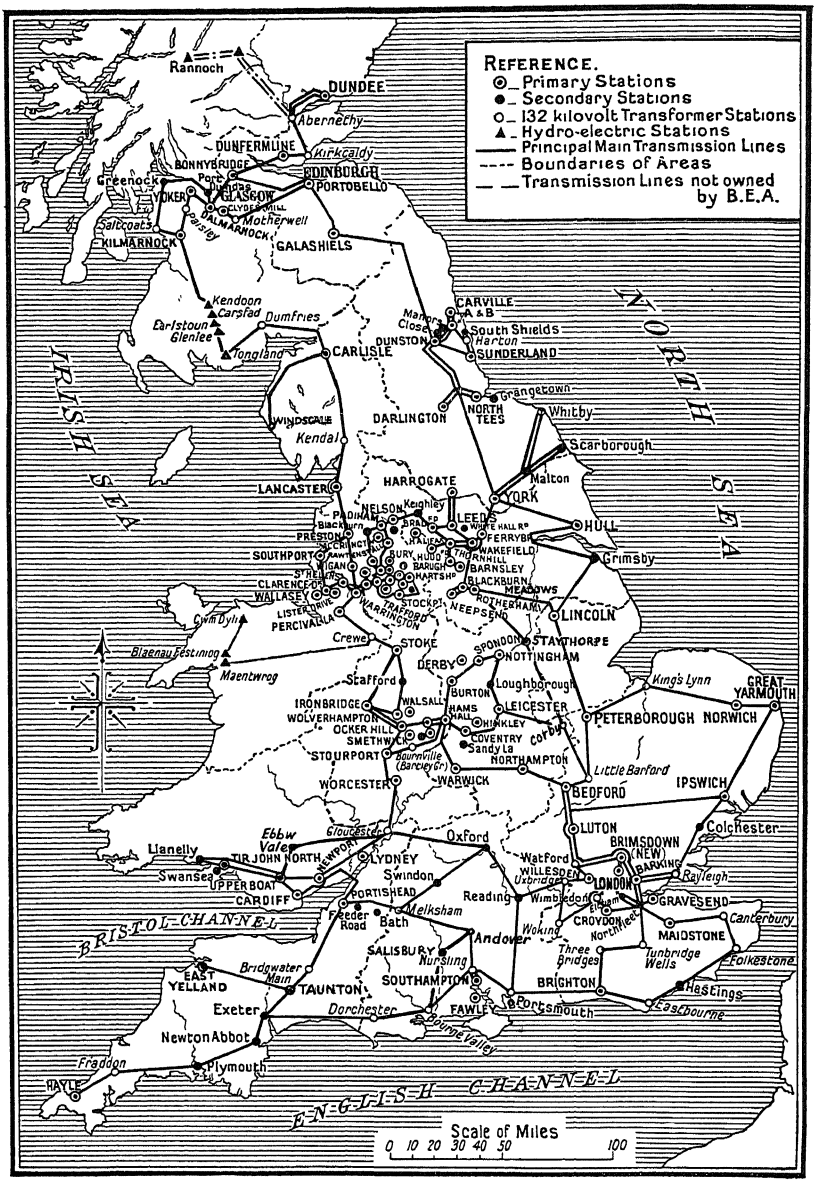
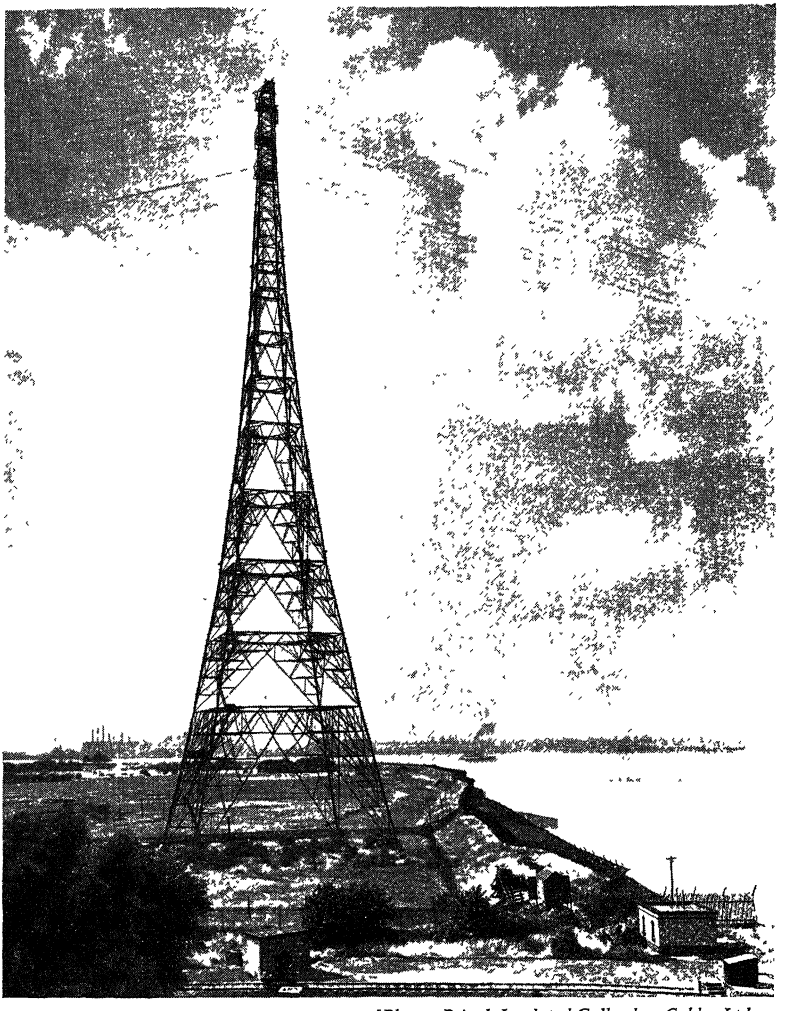


FIG. 233 —Map of the Main Grid Transmission Lines

women outnumbering the men in this industry[1] (see Chapter XXVIII). With regard to the *leather* industry, which in 1948 gave employment to nearly 34,000 people, the distribution of the occupa-



[*Photo British Insulated Callenders Cables Ltd.*

FIG. 234.—Power lines crossing the Thames at Dagenham

tion of tanning in these islands is one of very considerable interest. It is an old industry, and in medieval times the two great requirements were—(*a*) a supply of cattle-hides and sheepskins, and (*b*) a

[1] In 1948 (Census of Production), 5,400 out of 7,700 employees in the fur industry were in the London area, and they produced 72 per cent. of the total output by value.

supply of oak bark, since the principal source of the tanning extract was from this raw material. There was naturally a large and constant supply of hides from the damp cattle pastures of the Midlands of England, and consequently a tendency for the concentration of supplies in the market towns situated on the navigable rivers in the valleys of the region. Thus the tanning industry of Northampton, the natural geographical centre of the fertile river Nene basin, dates back a very long time. The oak forests which grew both on the damp lowlands of central England and also on the drier sandstone ridges, such as those of the Bunter sandstones, supplied the necessary tanning material. Another centre of early importance was the natural focus of the great agricultural region of East Anglia, that is, Norwich. At a later stage the home production of hides and skins no longer furnished sufficient material for the leather industry, and between 50 and 60 per cent. of the hides and skins used are now imported. The imports of hides are derived from the Argentine, the Union of South Africa, India, Eire and numerous other cattle-rearing countries. Sheepskins come naturally, in the main, from the great sheep-rearing countries of Australia, New Zealand, and the Union of South Africa; goatskins mainly from India. With this huge import of raw material it is natural that there should also be a large tanning industry at the great ports. Thus there are three types of area where tanning and leather-dressing are important at the present day:

(*a*) The old centres in the heart of the country districts, particularly in Northamptonshire and Leicestershire, associated with the manufacture of uppers for the boots and shoes industry, as well as in Somerset and other southern counties, where it was and often still is linked with local supplies of sheepskins and with the glove industry (see p. 562).

(*b*) In the vicinity of the great ports, particularly Merseyside (Liverpool, Warrington, and Runcorn), Bristol and London; here the emphasis (mainly the result of hide imports), is on heavy leathers for boot-soles.

(*c*) In the great inland conurbations (West Yorkshire, South Lancashire, and the West Midlands), where the market presented by various branches of the leather industry, particularly, in the textile districts, leather belting for driving machinery has been an influential factor.

The Boot and Shoe Industry, together with other Leather Manufactures

The small-scale making of leather goods is very widespread throughout the rural counties of England and Wales. These leather workers are, in the main, saddlers whose occupation is still one of importance although decreasing with the increased mechanisation of

agriculture. The factory industry, on the other hand, and the manufacture of bags, trunks, saddlery, and similar articles of leather, tends to be concentrated very much in the London area (which has 40 per cent. of the 15,000 people employed), and also in the Birmingham area, principally at Walsall. In the Middle Ages Birmingham was a natural centre on a somewhat infertile upland for the surrounding rich fertile lowlands, and as with the iron hardware industry (cf. pp. 424–5), the leather industry may be regarded as having grown out of this early response to local farming requirements and the local supplies of raw material. Although fabrics of very varied character now enter into the manufacture of women's shoes, the shoe-making and boot-making industry has largely grown out of the old leather industry; but it has become concentrated in a remarkable way in a few areas. Of over 110,000 factory workers, nearly 60,000, at the Census of Production in 1948, were in the north Midland Region, mainly Northamptonshire (Northampton, Rushden, Wellingborough, Kettering), and Leicester. Another leading centre is Norwich which at the present day specialises particularly in fancy footwear for women. In this case the industry was encouraged to replace the dying textile industry—which it has most successfully done. Other centres are Bristol and Stafford, and in Scotland, Kilmarnock.

The Clothing Trade

Every one must wear clothes; and the little dressmakers' and tailors' establishments which were so important in the past still persist in towns of almost every size up and down the country; indeed, in 1948 over 40 per cent. of all the 12,000 firms in the industry employed less than 10 persons each; but the large-scale manufacture of articles of clothing has become concentrated in a number of distinct centres, and it is perhaps because the requirements of clothing are broadly proportional to the population that these centres are the great conurbations. It would seem that the proximity of the market is more important than local supplies of raw material, though that too is seen to exercise an important influence in a number of areas. A leading place amongst the list of centres must be given to Leeds, not only because it contains the largest number of clothing operatives and because the variety of clothing trades carried on within its boundaries is very great, but because it is really the only large town of which clothing may be said to constitute the staple industry. The influence of the Yorkshire woollen industry is seen in the character of the clothing industry of Leeds, which specialises in outer garments of which wool is the chief material. In Lancashire, where Manchester is the principal clothing centre, dresses of light material, shirts, and underclothes are more important, obviously again indicating the importance of the local

supplies of cotton fabrics. The Manchester industry spreads to Stockport and to Wigan, whilst that of Leeds spreads to Halifax and Huddersfield. A third centre is afforded by Birmingham, Walsall, and neighbouring towns of the Midlands. A perhaps greater geographical interest attaches to the group of clothing manufacturing towns in the west of England of which Bristol is the centre; it also includes Gloucester and the Stroud valley, Taunton and elsewhere. Doubtless the clothing firms here are a legacy of the once important cloth industry now largely disappeared. It is natural that the hosiery centres of Nottingham, Leicester, and Kettering should not cease with the manufacture of knitwear, but should include also the manufacture of underclothing of different types. In the southern and eastern counties there are many towns, such as Colchester, Norwich, Portsmouth, Basingstoke, and Reading which have individually quite important clothing industries, but it is in Greater London that the industry is really important, the number of clothing workers being over 90,000 (see Chapter XXVIII). Luton, in Bedfordshire, is the chief centre in Britain for the manufacture of hat shapes, an interesting modern development of the former domestic industry in straw plaiting and weaving which in turn was the result of a situation in the midst of a rich cereal-growing country. In Scotland there is really only one important clothing centre—Glasgow. Reference is made in Chapter XXX to the clothing industry in Ireland.

Glove manufacture is a specialised branch of the clothing industry, linked, however, not with the main clothing industry but rather with the production of fine leather and with the West Country textile industry. Small towns in Worcestershire, Wiltshire, Dorset, and Oxfordshire contain much of the industry (nearly 40 per cent. of the 10,700 employees in 1948 were in the South-Western Region), which in part arose out of the declining woollen trades (cf. p. 486), and was accompanied by the development of small-scale tanneries for the local sheepskins which are still largely used.

Food Industries

Naturally, if one includes bakers, workers in the preparation of foodstuffs are very widespread throughout the country. In 1948, they numbered not far short of half a million. A map of the distribution of bakers and flour confectioners would show the same pattern as a population map, and some of the other food industries are also located mainly in the major urban centres, so that the London area is dominant almost throughout the table on p. 563, but in some cases other geographical or economic factors may be involved.

We may perhaps distinguish three types of location: (*a*) The larger towns, where industries may exist, based originally on local

EMPLOYMENT IN FOOD TRADES, 1948

Census of Production

Trade	Total (thousands)	Chief Regions[1] (Number employed in thousands)
Grain Milling	29	N.W. (6), London and S E. (5), E. (3).
Bread and Flour Confectionery	109	London and S.E. (26), N.W. (16), Midlands (11).
Biscuits	30	N.W. (7), London and S.E. (6), Scotland (6).
Bacon and Sausage	26	London and S.E. (5).
Preserved Meat	3	
Milk Products	46	N.W. (7), London and S.E. (7), Midlands (7), S.W. (6).
Sugar and Glucose	18	*
Cocoa, Chocolate, and Sugar Confectionery	56	Yorkshire (14), London and S.E. (11), Midlands (10).
Preserved Fruit and Vegetables	45	London and S.E. (12), N.W. (6), E. (6).
Miscellaneous preserved foods	27	London and S.E. (10), N.W. (4).
Brewing and Malting	72	London and S.E. (14), Midlands (11), N.W. (8).
Soft Drinks, etc.	25	London and S.E. (5).
Margarine	5	N.W. (3), London and S.E. (2).

* Not available, as several regions lumped together.
[1] Ministry of Labour Regions—see footnote to table on p. 427.

agricultural produce and often still in part dependent thereon—*e.g.* mustard at Norwich. In some cases perhaps a local traditional occupation has affected the establishment of allied factory industries, and Reading's biscuit manufacture may be an example of this. Certainly the fruit and vegetable preserving industries of such places as Peterborough, Wisbech, and Dundee come into this category. Rather different in character is the milk products industry which, though sometimes located in the market towns, is more commonly completely rural in location, depending upon good rail and road transport. The importance of the North-Western Region (which includes the Cheshire Plain), and of South-West England in this industry is clear from the table above (cf. pp. 204–5). (*b*) Certain types of food processing are naturally concentrated on the great ports where the imports (*e.g.* grain and sugar), arrive. Large-scale grain milling in particular tends to be concentrated at ports, notably Liverpool, London, Bristol, Hull, Southampton, and Manchester (though there are, of course, many inland flour mills, mainly served by rail or inland waterway). So does sugar refining, in which London and Liverpool again lead; and the manufacture of margarine (from imported fats) is another example. (*c*) Food industries, like

many other partly "footloose" industries, often exist in localities which have been chosen for essentially non-geographical reasons—*e.g.* the chocolate industries of Bournville (near Birmingham), and York. And food processing being often a "light industry," there are numerous examples of twentieth-century factories on the periphery of the great conurbations, or in trading estates, or more recently in the "Development Areas".

Paper

The manufacture of paper and cardboard is a widely distributed industry, and has been so ever since it began in the late fifteenth century. Formerly rags and abundant clear water were the main necessities; at the end of the eighteenth century there were over 500 small paper mills in the British Isles, all manually operated. Then water-power and bleaching chemicals became of importance and by about 1860, straw, mechanically-formed wood-pulp, chemical pulp and esparto grass had entered the field, largely to supplant the use of rags. Mills increased in size and decreased in number; by 1900 there were only 280, and the process of eliminating the smaller rural mills and concentrating on larger establishments has continued, so that the total is now about 228 mills. Water supply is still a major factor, since very large quantities (amounting to millions of gallons a day) are required by the mills; but facilities for the disposal of the effluent are almost of equal importance (compare artificial silk industry, p. 536). Soft water is desirable in general (and is always an asset where steam-driven plant is employed) but purity and freedom from colouring matter (particularly iron) are more important; hard water is not objectionable in the newsprint branch of the industry, since chalk is in any case often used as a filler for the paper.

The regional distribution of the paper industry (cf. employment table on p. 552) is as follows:—

Area	No. of Mills
Lancashire (and adjacent parts of Cheshire and Derbyshire)	38
Kent	32
S.W. England (Gloucester, Somerset, Devon)	22
Yorkshire	16
Chilterns (Bucks, Herts)	12
East Scotland (Fife, Stirling, Clackm.)	14
Midlothian	13
West Scotland (Lanark, Renfrew)	10
Aberdeen	6
Other areas	65
Total	228

The annual output of paper and board in recent years has been between 2½ and 2¾ million tons.

Two of the most important regions in the industry are the fringes of the Mid-Pennines and North Kent. In Lancashire and Yorkshire, pure water from the Millstone Grit, early water-power possibilities, later the ready availability of coal and chemicals and an abundant supply of cotton rags from the local textile industry, and then the proximity of the Mersey, Ribble, and Humber ports for the import of wood pulp and exports contributed to the rise and persistence of paper manufacture, while the large local population provides not only a market for the output but also a source of waste paper and rags as further raw materials. In the case of North Kent (Dartford—Gravesend and the Maidstone–Medway area) where a large proportion of the newsprint industry is concentrated, large water supplies from the Chalk, and river frontages for the disposal of effluent and the import of fuel and raw materials, together with the proximity of the enormous London market, have been the major factors involved.

There are many inland centres of paper-making, many of them of long standing and often highly specialised—e.g. banknote paper on the flanks of the Mendips, near Wells, fine writing paper and blotting paper at various mills in the Chilterns (e.g. Apsley, Loudwater), and fine transfer paper for the pottery industry at Cheddleton, near Leek.

In Scotland, paper-making also has a long history and a wide distribution. The Edinburgh district produces upwards of three-quarters of all the esparto paper in the country, and has long been famed for the variety and high quality of its products—which are much used locally in the stationery and printing trades, as well as having world-wide markets. Glasgow is the main newsprint centre, Aberdeen has several mills, and there are numerous other centres, mostly on the eastern side of the Central Lowlands, and mostly specialising in particular varieties of paper products.

Printing and Bookbinding

Of the workers enumerated in Great Britain, approximately one-third are located in the London area. Further, many printing firms have, for reasons of economy, migrated to towns which, although accessible from the metropolis, are outside it. Thus, this book is printed at Beccles, in Suffolk. Other well-known firms have chosen locations such as Colchester, Guildford, Maidstone, and Rochester. There is also still an interesting association between the printing, bookbinding, and publishing trades and the great centres of learning. One may cite particularly Edinburgh in the case of Scotland, and Oxford in the case of England.

The Rubber Industry

The rubber industry may be quoted as an example of an industry of comparatively recent origin which illustrates the varying strength

of factors determining location. The raw material is, of course, of equatorial or tropical origin, and must be imported. One would therefore expect the industry to be concentrated near the great ports. On the other hand the question of market arises. A large proportion of the rubber is required for tyres for the motor industry, and in connection with the electrical industries which have become established—particularly in South Lancashire and the West Midlands, where in 1948 just over half the workers in the rubber industry were located.

Oil Refining

The oil refining industry has undergone a major revolution since the Second World War. In 1947, about 2½ million tons of crude oil were refined in Great Britain; in 1953, no less than five major refineries each had an annual capacity greater than this, and the total reached about 26½ million tons. The reason for this vast expansion is mainly a simple economic one; crude oil costs much less to import than refined petroleum, and the dollar shortage made it vital to cut American imports and increase the importation of crude oil from the Middle East. Political considerations are also involved: the Arab embargo on the export of Middle East oil to the refinery at the Israel port of Haifa, and the Persian seizure of Abadan, were both factors increasing the desirability of expanding British refining capacity. Certain technical factors have also played a notable part: the refineries produce many by-products which can be used in other industries, and the petro-chemical industries (cf. Chapter XXII) have likewise rapidly expanded; and the variety of petroleum products now used by motor cars, tractors, diesel engines, and aircraft is such that it is obviously more economic to produce them from home refineries (which are supplied by large-capacity ocean tankers) than to import them separately.

PRODUCTION OF PETROLEUM REFINERY PRODUCTS, 1945 AND 1951
(thousand tons)

	1945	1951
Aviation and motor spirit	431	3,100
Other spirit	43	95
Kerosene	5	245
Gas oil and diesel oil	202	3,055
Fuel oil	199	8,502
Lubricating oil	254	412
Bitumen	279	746
Paraffin wax	11	15

Naturally enough, waterfront locations are chosen for oil refineries, since all the crude oil is imported; but because they require very large areas and are somewhat undesirable neighbours, they have

been built away from the major ports, and have had to develop their own port or pipeline facilities—as at Fawley, on Southampton water, at Stanlow, on the Mersey (linked by a 5-mile pipeline to a special dock at Eastham, recently built to accommodate modern 30,000-ton tankers—cf. p. 402), at Shellhaven and on the Isle of Grain, on the Essex and Kent shores, respectively, of the Thames Estuary, at Llandarcy, near Swansea (linked by pipeline to Queens Dock, Swansea), and at Grangemouth (linked by a 57-mile pipeline

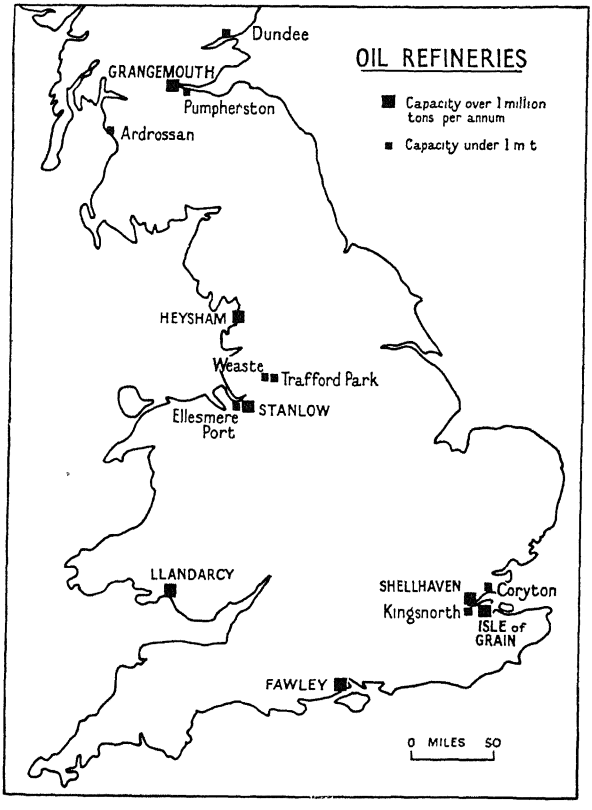


FIG. 235.—Petroleum Refineries, 1953

across the Scottish Lowland to a special quay on Loch Long, since the Forth estuary is too shallow for large tankers).

The location of the refineries facilitates an export trade which is growing rapidly. In 1945, the export of fuel oil in ships' bunkers totalled 1·7 million tons, and of fuel oil not for bunkers, only 1,000 tons. By 1951 the figures had risen to almost three million tons for bunkers and 2·3 millions not for bunkers.

Atomic Energy

While this book was in the press, information was made public for the first time about Britain's newest industry, the production of atomic energy materials.[1] The industry is noted in this chapter, but perhaps might equally well be regarded as either part of the chemical industry and of the engineering industry. None of the great new works is situated within the major industrial areas; each has grown out of wartime establishments which were intentionally placed out in the country. The largest and most important works is at Windscale, near Sellafield, on the coast of S.W. Cumberland: here plutonium is produced from uranium. Others are at Springfield, Lancs. and Capenhurst, near Chester; the main research establishment is at Harwell, near Didcot, in Berkshire. One of the main objects of the new industry is to make nuclear energy available for the generation of electricity and so save coal.

[1] Britain's Atomic Factories. H.M.S.O., 1954.

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Leather Trades Year Book.

CHAPTER XXIV

THE PEOPLING OF THE BRITISH ISLES[1]

Two sets of factors may be said to have exercised a dominating influence on the early peopling of the British Isles. The first set of factors is climatic, the second set of factors is physiographic. There is no doubt that there were human inhabitants in the British Isles before, or at least in the earliest stages of, the great Ice Age. As glacial conditions spread southwards so man was forced to retreat before the advancing cold, and River Drift or Palæolithic man left the open valley bottoms and took refuge in caves. But it is clearly incorrect to picture a continuous southward spread of glacial conditions and then a continuous northward retreat. Periods of intense glaciation were succeeded by comparatively warm inter-glacial periods which in turn were terminated by a renewed onset of colder conditions. The extremely difficult, if fascinating, work of correlating the glacial and inter-glacial deposits of this country and of tracing their connection with the movements of early man is one which has for long periods unceasingly occupied the attention of both geologists and archaeologists. If we consider the period of maximum extension of glaciation we may rightly picture the whole of Ireland and the whole of northern Britain, as far as a line joining the mouth of the Thames and the mouth of the Severn, as being covered by ice sheets of greater or less extent and of varied origin. At this period the extreme south of Britain, therefore, would be occupied by land comparable in climatic and probably in vegetational characteristics with the great Tundra lands of the present day. On these Tundras or Arctic grasslands the reindeer, amongst other animals, flourished, and attracted the attention of early man, the hunter. When the ice sheets finally retreated these Tundra grass-land conditions moved gradually northwards and probably man, still the hunter, went with them. The place of the Tundra in Britain was then gradually taken by forests. In recent years, especially as the result of the work of Dr. H. Godwin, precision has been given to the determination of climatic fluctuations during and since the Ice Age by the analysis of pollen grains found in the successive layers of peat deposits. Tundra conditions were succeeded by forests in which coniferous trees predominated whilst milder

[1] The authors wish to express their thanks to Professor H. J. Fleure and Professor W. G. East for their comments and criticism on the original draft of this chapter. Professor H. C. Darby has given invaluable help in the present revision of both this and the following chapter.

conditions were marked by an influx of deciduous trees. After several climatic cycles, the establishment of a mild, moist climate resulted in the general spread over the lowlands of the deciduous forests which form the characteristic natural vegetation of these islands at the present day.[1] The spread of forest increased the difficulty of sustaining life from the spoils of the chase, and so encouraged the settlement of man in more open areas on the uplands[2] and along the coast. The coast dwellers apparently obtained shell fish, and their implements are of "Tardenoisian" type. Later came the introduction of primitive agricultural and domestic animals, probably by invaders who were forerunners of the Megalithic and Beaker peoples. With the development of a more settled life there was no longer the necessity to be continually on the move, and several writers have properly stressed the importance of the change, especially on child life. No longer was it necessary for the children to be carried about continuously on their mothers' backs. Infant mortality lessened, and there was an increase in the population, and with the increase an improvement in moral and physical conditions. It must be remembered that simultaneously the great vegetation belts of the world which we know at the present day must have moved northwards, and this northward movement of environmental conditions with which they were familiar in itself encouraged the northward movement of peoples. This invited naturally a migration into, and a settlement of, Britain from the Continent.

The main physical features of the British Isles profoundly affected the lines of movement both of traders and of settlers. Prehistoric immigrants who entered Britain from the south or from the east spread westwards and northwards, though avoiding the thickly forested clay lowlands and using as their avenues of movement, for the most part, the more open hill-belts. Their movements were stopped, or at least hindered, by the hilly barriers afforded by the Pennines, the edge of the Welsh massif, and the hills of Devon and Cornwall. It might be thought that they would penetrate through what is now called the Midland Gate into the plain of Cheshire and Lancashire and thus reach the Irish Sea, but it would seem that that lowland was covered by a very heavy growth of damp forest which prevented access to the western seaboard. Later, it is clear that during the Roman period the settlements of the Romano-British population were in the main limited[3] to the "lowland zone," and it is still clearer when one comes to the succeeding period and considers the distribution of Anglo-Saxon settlements. On the other hand there was the stream of traders and settlers

[1] For a short summary see Chapter XIV of L. D. Stamp's *Britain's Structure and Scenery*, Collins' New Naturalist Library, 1946.

[2] E.g. the Pennines: see Petch *Publ. Tolson Museum, Huddersfield.*

[3] Recent work, especially by O. G. S. Crawford, has demonstrated the considerable extension of Roman control and influence into southern Scotland.

who approached the British Isles by the sea-way from the west and south-west. It is clear that, though they were able to spread over the whole of Ireland, their colonies were largely restricted to the coastlands of Devon, Cornwall, the Scillies, Wales (especially Glamorganshire, Pembrokeshire, Carnarvonshire, and Anglesey), the Isle of Man, the Western Isles and adjacent coasts of Scotland, Orkney, Shetland, the plain of Caithness, and the shores of the Moray Firth. Only when they had overcome the intervening mountain barriers—and still more the forest and marsh barriers—were they able to descend upon, or mingle with, the people of the lowlands to the east. It was not apparently till a much later stage, that of the Scandinavian invasions, that a movement of people coastwise from the north of Britain became important. There is, thus, in the peopling of Britain a fundamental distinction to be made between the lowland zone of the south and east and the highland zone of the north and west. Already, before the dawn of written history, a frontier region of peoples and cultures came into existence between the two. The dividing line between the zones corresponds roughly with the outcrop of the youngest Palaeozoic rocks—the boundary between Highland Britain and Lowland Britain already discussed in Chapter I. It would seem that the distinction between the two zones has been preserved for several reasons. Amongst them two stand out. One is that until the extensive clearance of forests in the lowland zone the habitable regions were mainly those raised some distance above sea-level, forming islands of habitable or cultivable land in a sea of forest, and where those more readily cultivable regions reached the coast there grew up the trading centres. By way of contrast the cultivable or habitable regions amongst the hills of Scotland or Wales were the valley regions, which may be described as islands of inhabitable country within a sea of comparatively useless hills. In the second place the lowland zone is that neighbouring to, and easily accessible from, the Continent, and so successive waves of invaders came in and imposed their culture, and often their racial characteristics, on the existing inhabitants. On the other hand, in the highland zone, such of the few invaders as penetrated into the valleys tended to be absorbed by the existing population. This is important, because it helps to explain the persistence of differences between the Highland Scot or the Welshman on the one hand, and the English lowlander on the other.

Some years ago, in a little book on the "Races of England and Wales,"[1] Professor H. J. Fleure presented a summary of the main results of research before 1920 on the pre-Roman peopling of the British Isles.[2] Later a particularly interesting and well illustrated

[1] Benn Brothers, Ltd., London, 1923.

[2] In 1951 Professor Fleure summarised his long life's work in this field in *A Natural History of Man in Britain*, Collins' New Naturalist Library.

summary was drawn up by Sir Cyril Fox and has since passed through a succession of editions.[1] Fox shows how after the final retreat of the ice, but earlier than 2000 B.C., a powerful Megalithic civilisation spread over the whole of Ireland and the highland zone of Britain, including the plateau of Caithness and the lowlands round the Moray Firth. The culture had been brought by sea from the south and west, that is from Spain and Atlantic France. The invaders were the builders of the dolmens and other huge stone monuments which are still found widely distributed in Ireland. In Britain they evidently pressed eastwards, and the stone circles of Stonehenge and Avebury are evidence of the importance of their dominance in the Salisbury Plain region. Forty of the lesser stones of Stonehenge were actually transported from Pembrokeshire. The builders of the great stone monuments seem to have been longheaded people, probably of short stature and dark skin, and the evidence points to them as the oldest large element in our population. They buried their dead in long barrows, and hence they are sometimes known as "long barrow" people.[2] Simultaneously the east of Britain seems to have been strongly influenced by a Neolithic culture of peoples coming from the east, from the Baltic region, or possibly from farther eastwards from the Kiev region or from Upper Silesia, passing on their way to Britain through Denmark and Holland. In Britain, the remains of these people, often known as the "Beaker" people as they are associated with rough pottery of curious form known as beaker pots, are left most characteristically along the east coast from Caithness to the Humber, and in the south-east,

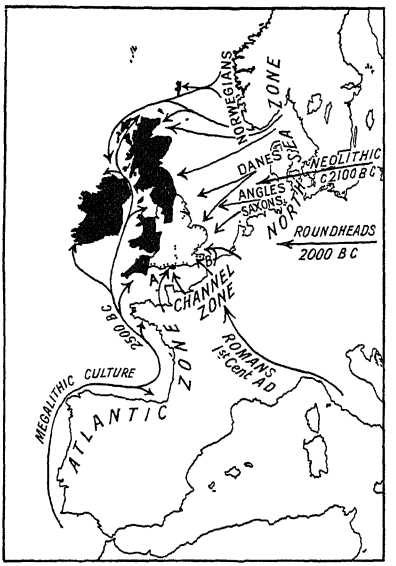

FIG. 236.—The routes from Europe into Britain followed by early traders and invaders

The "highland zone" is shown in black, the "lowland zone" by dots. A and B=routes followed by invaders and traders of the late Bronze Age, B=routes followed by Romans.

[1] *The Personality of Britain—its Influence on Inhabitant and Invader in Prehistoric and Early Historic Times.* National Museum of Wales, Cardiff, First Edition, 1932, Fourth Edition, 1950.

[2] Some authorities regard the long barrows as a variety of megalith belonging to a zone farther east than the true megalith and of doubtful cultural derivation.

where they evidently penetrated along the chalk ridges. If the earliest arrivals brought no metal, copper, and bronze daggers were a little later commonly buried with the dead. They buried their dead in round barrows. Burials of the succeeding stage were also in round barrows, but usually in cinerary urns, since by that time the corpses were generally burnt. The Beaker people were short-headed people, thus allied in character to the Alpine race of the Continent of Europe, or perhaps a Nordic-Alpine cross, whereas the Megalithic people may be said to be allied to the Mediterranean races of Europe. For the next stage in the peopling of Britain Fox gives the provisional date of about 2000 B.C. The invaders were from the east, the Nordic-Alpine roundheads (predominantly but not exclusively roundheaded) who came and occupied the whole of the lowland zone and penetrated far into the highland zone. They made Salisbury Plain an important centre and assimilated some of the Megalithic traditions and possibly reconstructed Stonehenge. The trade from the south-west also developed at this time and the Hampshire "Gate" seems to have been used for the importation of bronze tools which were taken *via* Salisbury Plain to the Midlands and possibly through the Bala cleft into Wales. Many of the people of the south-eastern lowlands, however, were too poor at the time to acquire these imported tools. Almost contemporary with this, Fox says, a new source of copper and bronze tools was opened up in Ireland, and these Irish products were traded in both highland and lowland Britain. There was at this time an important trade in Irish gold (obtained in the Wicklow Mountains) to the Continent, and this trade seems to have been captured by the lowland people of Britain. By 1000 B.C. (in the late Bronze Age) there was marked activity in trading. New invaders brought with them a high culture, and developed metallurgy, particularly the art of bronze working, in Britain itself. They entered the country by the east and south coast estuaries and seem to have been most active in the Thames Basin—the middle and lower Thames valley. Here during the last five centuries B.C. the Bronze Age gave place to the Iron Age, and close contact developed between the iron-sword makers of south-eastern England (Iron Age "A" culture) and the neighbouring parts of the Continent, with the result that the south-east had a cultural pre-eminence, and strong British kingdoms had their capitals at St. Albans and Colchester. At the same time there seems to have been an important cultural centre (Iron Age "B" culture) in the south-west, probably connected with the exploitation of Cornish tin, and the consequent stimulation of the old sea routes to the south-west.

In A.D. 43 the Roman conquest of Britain began by an entry in the south-east and an advance north-westwards towards the Thames. A Roman commercial centre was quickly established at

London, and a uniform control was imposed on the lowlands. Two maps are given here to illustrate the Roman occupation of Britain. The first shows the area with civil settlements in Roman Britain, and the remarkable way in which the civil districts correspond to what has been described in this work as the "lowland zone" will be noticed at once. The Romans established cities and farms (*villae*), and made their long straight roads all over the lowland zone. In the highland zone they established military camps and military districts, but not Romanised civil settlements, though roads were extended from the lowlands into the highlands. This is shown very clearly in the second map. The distribution of Roman

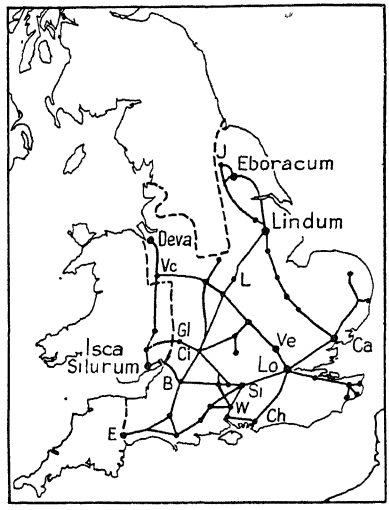

FIG. 237.—The Civil Districts of Roman Britain (after Haverfield and Macdonald)

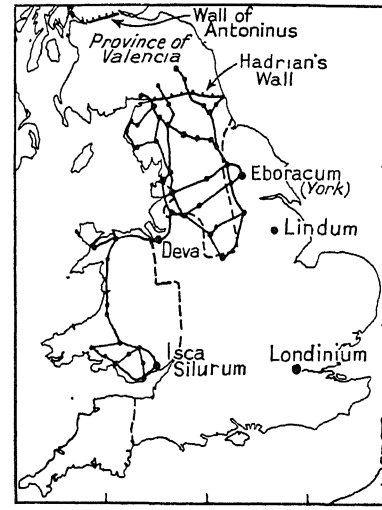

FIG. 238.—The Military Districts of Roman Britain (after Haverfield and Macdonald)

The chief Roman roads connecting (Fig 237) the civil settlements, and (Fig 238) the military posts

villas in the country—almost restricted to the lowland zone—illustrates once again the significance of the division between these two fundamental parts of Britain. After some four centuries of occupation, the breaking up of the Roman Empire resulted in the withdrawal of all Romans from Britain.

In the fifth and sixth centuries A.D. history repeated itself. This was the period of the invasions, conquest and colonisation of the British lowlands by the barbarian Angles and Saxons. The maps, Figs. 239, 240, show clearly how the political and cultural division of England in the sixth century A.D. illustrate once more the contrast between the Lowland Zone and the Highland Zone; the Lowland Zone completely Anglo-Saxon, the Highland Zone

remaining Celtic. Thus, since the Anglo-Saxons were pagans at first, the Celtic Christian Church was cut off from the Roman Christian Church of the Continent. Many of the earlier writers on the early history of Britain fell into the error of thinking that all invasions of Britain—cultural and military—had come from the east, and that each invasion in turn had pushed the earlier peoples into the highland fastnesses of Scotland and Wales, and into the outpost of Ireland. We have seen that this is fundamentally wrong; and it can again be proved so during the fourth, fifth, and sixth centuries A.D. when there was extensive colonisation from Ireland of the western coasts

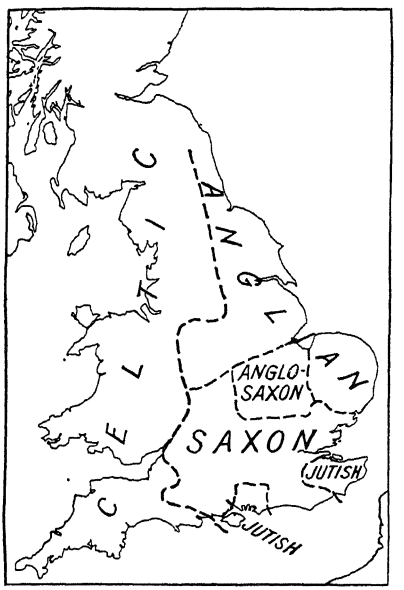

FIG. 239.—Cultural zones of the Angles, Saxons, and Jutes in Britain A.D.*c.* 550 (after E. T. Leeds)

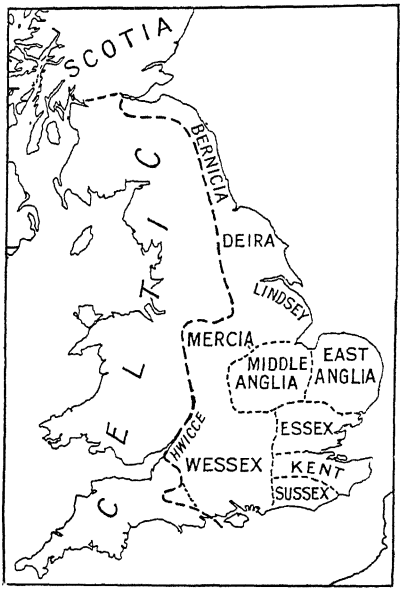

FIG. 240.—Anglo-Saxon Britain at the end of the sixth century A.D., showing the kingdoms. Notice the significance of the Forth as a barrier (after E. T. Leeds)

of Scotland (where the Scots from Ireland drove out the native Picts in Argyllshire), Wales, the south-western peninsula and Brittany; and it was indeed the coming of these Irish to western Britain that spread alarm in the waning years of Roman rule. The Anglo-Saxon colonisation largely "fixed" the settlements of at least the lowland zone and the process was later extended.

It was in the eighth, ninth, and tenth centuries A.D. that a new movement of invasion and colonisation occurred which had a lasting influence on parts of Britain. This was the invasion of Vikings or Norse and Danes which was mainly from the north-east. The Norse colonised the Shetlands and Orkneys, and a broad coastal

fringe of northern Scotland, including most of Caithness.[1] The Danes colonised many places, as the distribution of place names shows, in eastern Britain, tending to remain on the whole along the coast, though spreading far inland along the estuaries of navigable rivers. The name Danelaw is given to those districts of north-east and eastern England conquered by the Danes in the ninth and tenth centuries and in which Danish customary law prevailed. The stand made by King Alfred prevented the Danes from engulfing

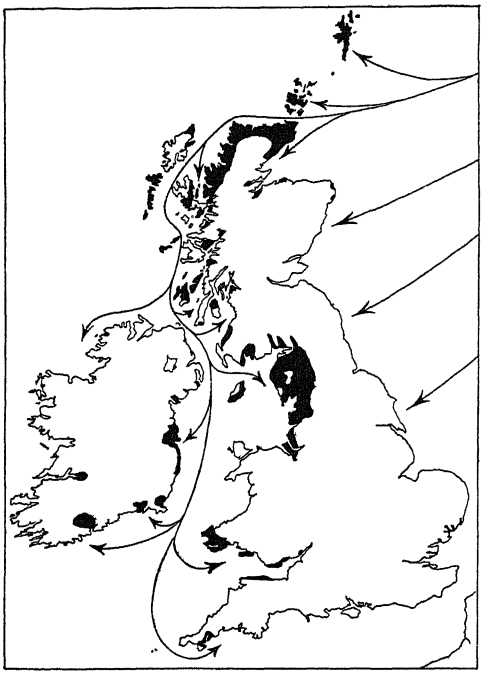

FIG. 241.—The Viking Settlements of the eighth, ninth, and tenth centuries

Wessex and between 880 and 890 a line running north-west from the River Lea roughly along the line of Watling Street was agreed as the western limit of the Danish domains, but by 920 the Danes were conquered. Another stream of Norse invaders had passed down the western coast of Scotland, colonising at intervals as they went, and forming a broad area of settlement in what is now the Lake District, the Isle of Man, and Lancashire. They showed themselves adept at recognising the more important ports of entry into Ireland, colonising round Dublin, Waterford, Cork, and

[1] The Viking invasions so weakened the Picts of Scotland that they were conquered with ease by the Scots under Kenneth Mac Alpine, who thus became the ruler of the united Picts and Scots.

Limerick. In the meantime, it should be noticed, the Anglo-Saxons had penetrated farther northwards and had colonised the east of the Midland Valley of Scotland as far north as the Forth, where Lothian formed the northern part of the Kingdom of Bernicia.[1] Thus we see the British Isles at the time of the Norman Conquest in 1066 with an Anglo-Saxon or Lowland Zone, a Celtic-speaking Highland Zone, and an important Scandinavian fringe. The Romans had imposed their rule and to some degree their language, but can scarcely be said to have altered the racial characteristics of the inhabitants of these islands. In any case the Romano-British inhabitants were submerged by the Anglo-Saxon flood. The Norman invasion reinforced and partly replaced by their feudal system an aristocracy which had already been established.

An immense wealth of information concerning Britain in the latter part of the 11th century is contained in the Domesday Book. For long, difficulties of interpretation resulted in this material being neglected in its geographical aspects until a team of workers under the general direction of Professor H. C. Darby undertook a systematic study county by county.[2]

The emergence of the English people as a whole really dates from the days of Chaucer (*c.* 1340–1400) who was the first great writer to use the English language as opposed to Anglo-Saxon or Norman French. After the Norman conquest, there was no mass invasion of the country, but there were certain population movements. One of these was the influx of Flemings and Huguenot refugees, which had an important and lasting effect on the development of economic life in this country.[3] Another was the intermittent incursions and peaceful settlement of western Scotland by migrants from Ireland, particularly early in the seventeenth century during the reign of James I of England.

Having learnt now something of the various strains of people that have gone to make up the British nation, we may turn to a consideration of the distribution of population in the islands.

To Scotland falls the honour of having taken the first census in Britain, compiled in 1755 by Dr. Alexander Webster, minister of the Tolbooth Church in Edinburgh. Webster used his influential position as Moderator of the General Assembly in 1753 to secure from the parish ministers a return of the number of souls in their parishes, differentiating the two groups of Protestants and Papists.

[1] On the importance of the Firth of Forth as a geographical barrier and the origin of the present Scottish counties, see W. C. Dickinson, "The Sheriff Court Book of Fife," *Scottish History Society*, 1928.

[2] The first of six volumes was published by the Cambridge University Press in 1952. Reference should also be made to Professor Darby's paper on "The Changing English Landscape" which he gave to the Royal Geographical Society in January 1951.

[3] See pages 460–1.

These early records of Scotland are particularly interesting since they show the distribution of population just prior to the period when Scotland changed from an agricultural and fishing country to one characterised by large scale industrialisation in the Central Valley. Thus, in 1755, the most densely populated counties in order were Banff, Berwick, Midlothian, Clackmannan, Fife, and West Lothian, all, it will be noticed, on the drier eastern side of the country which has already been shown (see Chapter XI) to be the most suitable agriculturally to support a considerable population. It will be seen that the Midland Valley counties had not at this time succeeded in drawing to themselves the large populations which characterised them shortly after. It was largely owing to the influence of Malthus and the not inconsiderable stir that his predictions produced that the first official census of the British Isles was taken in 1801. From that time onwards the census was taken every ten years until 1931, and the table given below shows the population of each of the constituent parts of the British Isles at each census and also the decennial rate of change. Throughout, the rapid increase at first and then the diminishing rate of increase is clearly indicated. An attempt has also been made to incorporate the effects of migration. Of course the key note of the last hundred years has been industrialisation—the increase of the industrial and urban population—accompanied by rural depopulation. An actual decrease in population did not set in as a rule until about the middle of last century or later. A study of the movement of population county by county, indicates at first a rise, practically speaking, in all counties, then a general decrease in the rural counties, but continued

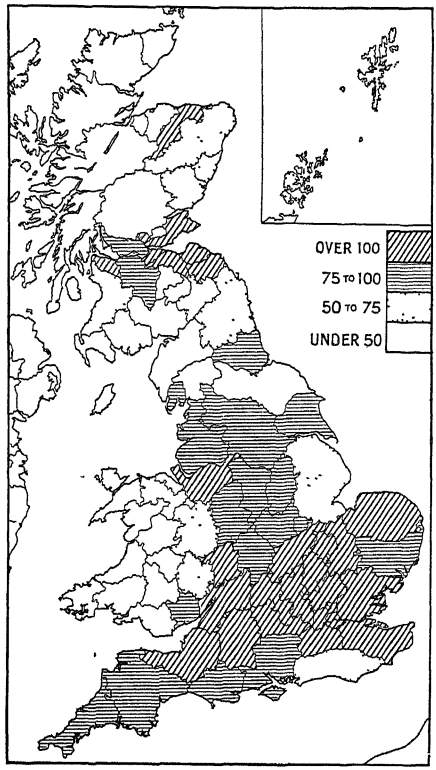

FIG. 242.—The population of Britain in 1700 per square mile (Scotland in 1755)

The densest population was in the better agricultural areas: the coalfields had not yet exerted their influence

increase in all those counties which had industries. Quite frequently even the possession of a small industrial tract on the county margins was quite sufficient to turn the scale as, for example, in Denbighshire and Flintshire in Wales.

In general terms it may be said that there are in Britain two superimposed population patterns. One is the rural-agricultural with

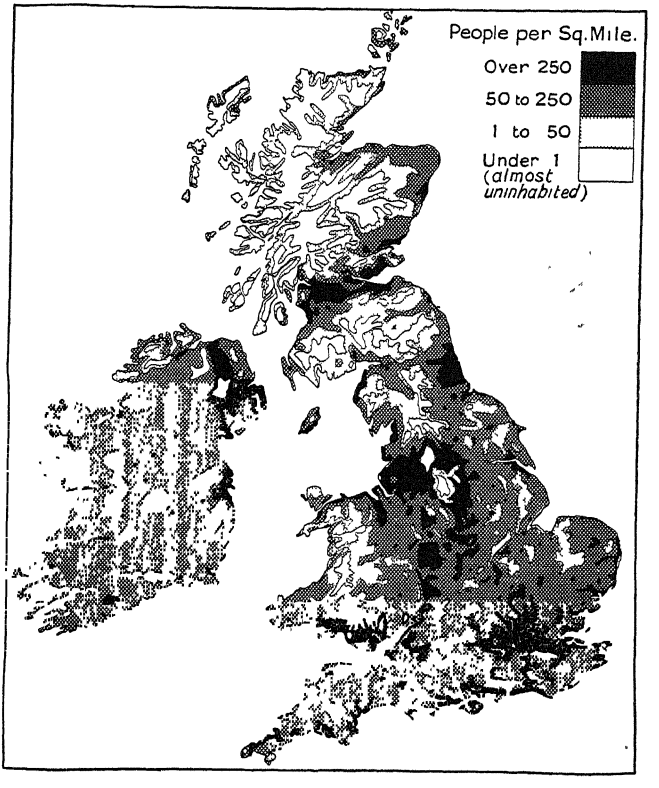

FIG. 243.—The population of the British Isles in 1931

The divisions correspond roughly with industrial and intensive agricultural, good agricultural, poor agricultural, and remote moorland tracts

its isolated farms and farm-workers' cottages, villages and market towns, the whole strongly influenced by quality of land. The other is the urban-industrial, still expanding and spreading over the older pattern. At the present day rural depopulation is not an indication of decadence but of increasing agricultural efficiency—less labour needed to maintain production.[1]

[1] In some areas the 1951 Census revealed a rise in the population of Rural Districts and hence an apparent rise in the population officially classed as rural. Actually the increase represented an overspill from the towns into the surrounding rural districts.

Because the general movement of population has long been from the country to the towns it must not be presumed that all towns have increased in size. The rise and fall of settlements will be discussed in the next chapter. But whilst continued growth is the rule in the great urban agglomerations, which once they attain a certain

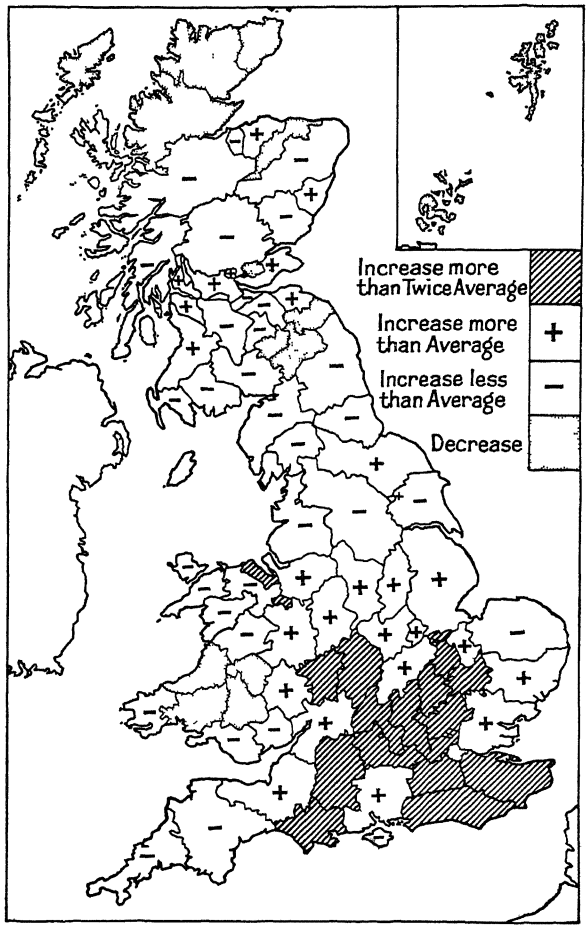

FIG. 244.—Population changes in Britain 1931–1951, illustrating rural depopulation

size tend to increase of their own momentum, some of the smaller towns, especially those in Scotland, are losing their population at a greater rate than even the purely rural parishes. It is scarcely necessary to emphasise the way in which the coalfields have been the magnet for the attraction both of industries and the population which went with the development of industries. Exceptions were

few. Naturally some of the larger ports continued to attract a population as their trade developed, but in reality they were serving for the most part as inlets or outlets for the industrial regions on the coalfields. The one main exception was London, in so far as its relationship to the coalfields is concerned, but after all London is really the port for the greater part of Britain. But post-1918 years brought about a distinctly new tendency. It may be described as the flight of industry *from* the coalfields, in large measure of course due to the more extensive use of electricity which can be generated on the coalfields or from water-borne coal and transmitted where required. To sum up, the tendencies in the intercensal period of 1921–1931 may be described as showing continued rural depopulation, virtual or actual cessation of growth, and in cases even a decrease in the population of industrial regions and towns in the north compensated for by the continued phenomenal growth of London and of the development of the London region as a whole as a manufacturing area.

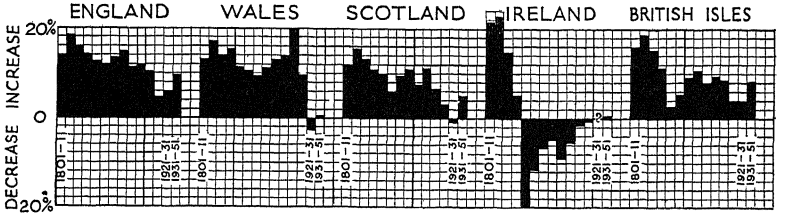

FIG. 245.—Population changes in the British Isles, 1801–1951, showing decennial changes

The main areas of really marked population increase were Greater London and Greater Birmingham. It was said that industry was moving south—actually what was happening was the establishment of new industries and new factories in the south and midlands whereas in the older industrial areas obsolescent and abandoned factories were not being replaced. This meant that in the older peripheral areas there was much unemployment and taxes collected from the businesses of the prosperous centre were being used to relieve distress there. The Report of the Royal Commission on the Geographical Location of the Industrial Population (Barlow Report) recommended that there should be a national plan to secure a wider distribution of industry. This dispersal of industry was in fact secured by the war-time conditions of 1939–1945 and is now part of national policy. It is made easy for manufacturers to establish new factories or industries in the "Development Areas" of South Wales, West Cumberland, Central Scotland and Northumberland–Durham—to name the chief. Despite official deterrents the results of the 1951 Census showed a continued increase in the "belt"

stretching from Lancashire on the one hand to London on the other.[1]

At first it might be thought that Ireland offers a different picture from Britain. But that is not actually the case. Ireland is essentially rural, and so has suffered depopulation in the same way as all rural parts of the British Isles. But as the diagram (Fig. 245) shows, depopulation was continuous from the decade 1841–1851 to 1921 and was initiated by the great famines of the 'forties.

POPULATION

	British Isles	England and Wales	Scotland	Ireland
1801	—	8,892,536	1,608,420	—
1811	—	10,164,256	1,805,864	—
1821	20,893,584	12,000,236	2,091,521	6,801,827
1831	24,028,584	13,896,797	2,364,386	7,767,401
1841	26,730,929	15,914,148	2,620,184	8,196,597
1851	27,390,629	17,927,609	2,888,742	6,574,278
1861	28,927,485	20,066,224	3,062,294	5,798,967
1871	31,484,661	22,712,266	3,360,018	5,412,377
1881	34,884,848	25,974,439	3,735,573	5,174,836
1891	37,732,922	29,002,525	4,025,647	4,704,750
1901	41,458,721	32,527,843	4,472,103	4,458,775
1911	45,213,347	36,070,492	4,760,904	4,381,951
1921	—	37,886,699	4,882,497	4,228,553[1]
1931	—	39,952,377	4,842,554	
1951	53,327,333	43,744,924	5,095,969	4,329,587

[1] Census year 1926 for Irish Free State and Northern Ireland.

DECENNIAL POPULATION CHANGES (PERCENTAGES)

	British Isles	England and Wales	Scotland	Ireland
1801–11	—	14·00	12·3	—
1811–21	—	18·06	15·8	—
1821–31	15·03	15·80	13·0	14·3
1831–41	11·24	14·27	10·8	5·5
1841–51	2·47	12·65	10·2	−19·8
1851–61	5·62	11·90	6·0	−11·8
1861–71	8·55	13·21	9·7	−6·7
1871–81	10·80	14·36	11·2	−4·4
1881–91	8·16	11·65	7·8	−9·1
1891–1901	9·89	12·17	11·1	−5·2
1901–11	9·04	10·89	6·5	−1·7
1911–21	—	4·93	2·6	−3·4[1]
1921–31	—	5·16	−0·8	
1931–51	—	9·5	5·2	2·4[2]

[1] 1911–1926. [2] 1926–1951.

Owing to the Second World War there was no Census in 1941. The figures in the bottom row thus refer to 20 years.

[1] There has been much discussion on the reality or otherwise of this "belt." See *Geog. Jour.* CIII, 1944, 49–72; also A. E. Smailes, in *Geography*, XXIX, 1944, 41–51.

NOTE

The population of the Irish Republic decreased from 2,971,992 in 1926 to 2,965,854 in 1936 and to 2,960,593 in 1951, the period 1946–1951 showing a slight increase.

NUMBER OF PASSENGERS OF BRITISH NATIONALITY LEAVING AND ENTERING THE UNITED KINGDOM FOR AND FROM COUNTRIES OUTSIDE EUROPE (THOUSANDS)[1]

	1909–13	1926	1930	1933	1935	1938	1946	1950
Emigrants:								
To the Commonwealth .	276 3	132·3	59 2	20 8	24·3	29 0	110·2	112·9
To foreign countries . . .		166·6	32 9	5·5	5 5	5 1	56·6	17·3
Immigrants.								
From the Commonwealth	104 3	39 1	51 4	44 6	35·8	32 6	54·1	56·1
From foreign countries . .		12 0	14 8	14·7	10 5	8 0	9·0	10·0

[1] From Statistical Abstract of United Kingdom and Annual Abstract of Statistics. 1926 was a peak year for emigration after the War, 1933 a low record.

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CHAPTER XXV

THE EVOLUTION OF THE FORM AND FUNCTIONS OF BRITISH VILLAGES AND TOWNS

IT seems clear that the settlements of Stone Age man were restricted to those areas where the natural vegetation cover was easily cleared (see p. 573). That such areas were available on the comparatively open belts, such as the chalk downlands of south-eastern England, is reasonably certain (but see p. 135), but it has been urged also that there were other sites, notably gravel plains in the valleys, which were equally attractive.[1] As our knowledge of post-glacial climatic fluctuations increases it becomes clear that in pre-Roman Britain when Neolithic man and his successors occupied the land the climate of these islands was more humid than at present, and that water supply in upland situations did not present the difficulty that it would do to-day. The Briton at the time of the first Roman raids relied upon the hoe for scratching the surface of the small square fields which he had cleared on the uplands or on the valley gravels, and this field system appears to have continued during the Roman occupation. The network of straight roads linking strategically sited towns developed by the Romans bore no relation to the agricultural land use pattern of the earlier inhabitants. When the Romans withdrew, the earlier Anglo-Saxon invaders came as warring conquerors, who seem almost to have eliminated the Romano-British inhabitants, although this is debateable. But later they appear as land-hungry settlers, penetrating by water routes to almost every part of Lowland Britain. It seems clear that the introduction of the eight-ox plough in Anglo-Saxon times produced a revolution in agricultural practice. In the words of H. J. E. Peake,[2] "it ceased to be economical, or even practical, to plough these little chessboard squares; for when the peasants adopted the new method of cultivation they divided the land into long narrow strips that were suitable for ploughing."[3] Whatever the origin of the common-field system with its two or three fields, it is certain that by early Saxon times the normal human settlement had five

[1] E. T. Leeds· *Geography*, XIV, 1928, pp. 527–535. Probably, as suggested on p. 142, the alder-woodland of these damp areas was more easily attacked by men armed only with stone tools than oakwood or other types of forest.

[2] "Geographical Aspects of Administrative Areas," *Geography*, XV, 1930, pp. 531–546.

[3] The acre consists of four roods, each a rod wide and a "furrow long" or "furlong" in length.

primary requirements. (1) A supply of water; (2) an area of good lowland grazing, *e.g.* meadows on alluvium or by the side of streams; (3) Drier undulating land suitable for ploughing; (4) an area of common rough hill pasture for grazing. Such comprised a typical valley settlement; (5) a woodland area for fuel and building material. In the broader valleys the settlements would be on the banks of the stream, and the land proper to the village would extend from the damp pastures along the banks of the stream to the high

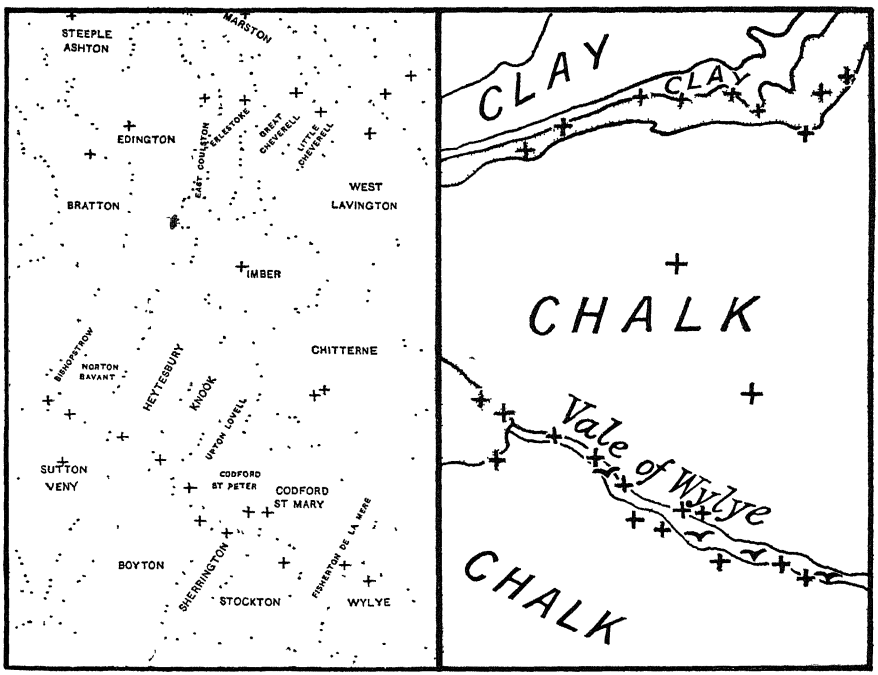


FIG. 246.—Wiltshire parishes

Illustrating a line of valley settlements along the Vale of Wylye, with the village (the cross represents the parish church) near the stream in each case. In the north are "spring line" villages along the outcrop of the water-bearing Upper Greensand on the southern side of the Vale of Pewsey. (Scale 4 miles = 1 inch)

ground on one side of the valley. The villages might be at intervals of a mile or more along the banks with a corresponding line along the other side of the stream. In the case of narrower valleys the village itself might bridge the stream and its domain extend from the hills on one side to the hills on the other. In other cases a line of villages might be situated along a line of springs issuing from the hillside, the pasture land occupying the lower ground to the one side, the ploughed land and the rough pasture the higher ground to the

other, giving what are known to-day as spring line villages.[1] It is thus clear how the vill or smallest unit of administration came into existence. It was the land proper to a single village or settlement and its boundaries were naturally so arranged that it included areas of the three types of land mentioned.[2] With the reintroduction of Christianity into Britain at the end of the sixth century A.D., it is natural that a church should be added to the existing settlements, and the vill took on a new aspect; it became the parish, the smallest unit of our existing administrative system and originally a purely ecclesiastical area. It was the district served by the parish church and indeed the area from which tithe is payable to a given church,

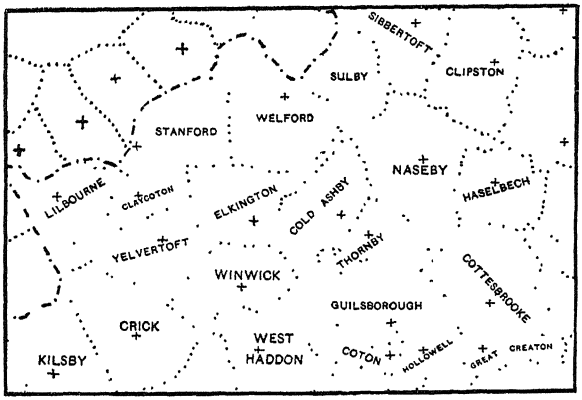


FIG. 247.—Regular-shaped parishes with the church or village centrally placed

Typical of the damp pasture lands—now predominantly permanent grassland—of the Midlands and clay vales. (Scale 4 miles = 1 inch)

or in the first instance to the priest in charge. Examples are numerous in south-eastern England of the apparently curious shape of parish boundaries which are due to the old-time necessity of including within the parish sufficient areas of the land of different types required by the rural economy of the period. Excellent examples are afforded in the south of Surrey in the parishes of Wootton, Abinger, etc. With the development of the manorial system sometimes the vill or township coincided not only with the parish but also with the manor. Sometimes, however, the vill had become divided into two or more manors, each of which had a parish church and so each became a distinct parish. Often the component parts

[1] Both types of village correspond to what some continental authors have called "wet point villages." It is only in the wet marshy districts, *e.g.* plain of Somerset, that there is the necessity for the human settlement to occupy a drier point than the surrounding marshy lowlands, giving what may be termed a "dry point" village. See B. M. Swainson, "Rural Settlement in Somerset," *Geography*, XX, 1935, 112–124.

[2] Vill seems a better term for these units than township, which tends to suggest an urban area.

in the original vill retained the old name, distinguished, however, by the addition of an adjective—such as the name of the lord of the manor or the saint to which the church was dedicated. Many of the picturesque names in the lowland counties of England are thus derived.[1] It is clear that the typical arrangement just described would be characteristic of predominantly arable areas, but it must be remembered that large tracts of the wetter lowlands of England remained for long under damp oakwood. Probably the earliest settlements in these were mere clearings in the forest, that is, isolated homesteads. Later much of the damp oakwood became replaced by permanent pasture, and to this day in England the pastoral counties are characterised by disseminated settlements or isolated farms, whereas arable areas are characterised by the nucleated village.[2] Even when a number of the pioneer settlers were close together and formed a hamlet the population of the whole area would remain scanty and probably also poor. Not one of these hamlets or small vills would be sufficiently rich to support a church and a priest, and so in such areas of Britain as Cheshire and Shropshire, and the Marches of Wales, a church had to serve a large area of this sparsely peopled country, and a parish came to consist of as many as 10–20 of the small vills or townships. Not infrequently these larger churches, collegiate churches as they were afterwards known, had two rectors; probably the duty of one being to tour the large parish. Such large parishes of the west seem to have been designed to provide the maximum of convenience to their population. Although they are large they are usually roughly circular or oval without awkward prolongations, and the parish church is generally to be found near the centre. On the other hand, there are large, and often irregularly shaped, parishes in the arable eastern counties due to the action of lords of the manor. Where one man held a lordship over two or three adjoining manors he tended, for the sake of economy, to combine these and to be satisfied with one church and one priest for the whole of his estate. Some of the still more irregularly shaped and unwieldy parishes owe their origin

[1] *E.g.* Compton Bassett, Berwick Bassett, Winterbourne Bassett (Wiltshire), Wiggenhall St. Germans, Wiggenhall St. Peter, Wiggenhall St. Mary the Virgin, Wiggenhall St. Mary Magdalene (Norfolk).

[2] See P. W. Bryan, *Man's Adaptation of Nature*, London, University of London Press, 1932. Also E. E. Field, *Rural Settlements in Northamptonshire.* Thesis presented for the degree of Ph.D. in the University of London, 1931. (Unpublished.) But in many cases when it was supposed that the isolated homestead was the original form of settlement, the supposition has been disproved. By way of contrast for different areas see E. G. Bowen, "A Study of Rural Settlement in South-west Wales," *Geog. Teacher*, XIII, 1926; H. King, "The Geography of Settlements in South-west Lancashire," *Geography*, XIV, 1927 193–200, and *Jour. Manchester Geog. Soc.*, XXXIX–IXL, 137–144; Dorothy Sylvester, "The Hill Villages of England and Wales," *Geog. Jour.*, CX, 1948, 76–93. See also H. J. E. Peake, "Geographical Aspects of Administrative Areas," *Geography*, XV, 1930, 531–546 and H. Thorpe, "The Green Villages of County Durham," *Inst. Brit. Geog.* Pub. 15, 1949, 155–180.

to the action of the monasteries, who endeavoured to augment their incomes from tithes by combining parishes irrespective of their boundaries, grouping them around the parish church which belonged to the monastery. This practice seems to have been prohibited in 1123, but already by that time a number of large and awkwardly shaped parishes that contradict all rational geographical principles had been formed. Each had, of course, one parish church, and the churches which had previously been parish churches, and which were still included within the boundaries, became chapels or chapels of ease. Other chapels of ease were often erected in large and populous parishes.

But most of the parishes of Britain are of very ancient origin, and retained their boundaries until a little over a century ago, when in the early part of the nineteenth century the growth of population, consequent upon the Industrial Revolution, necessitated the frequent carving up of very populous parishes into smaller units. Even this practice was not general until after the passing of an act in 1856. It should be noticed that until Tudor times the parish had been a purely ecclesiastical unit, and it was not until the decay of the manor following the Black Death and the first agrarian revolution that the parish became a civil unit. When parish councils were created by the Local Government Act of 1894, the civil parishes almost invariably coincided with the ecclesiastical parishes. County councils were given power to sub-divide large parishes, and although the power was not very widely exercised,[1] where it was, the new civil parishes were made to follow the ancient boundaries of the vills or townships. This was done, for example, in Cheshire.

Returning now to the old vills or townships—these were grouped into hundreds which normally consisted of ten or twelve townships, at least in south-eastern England.[2] In the north-eastern counties of England under Danish influence larger units were formed known as wapentakes. Many of the old hundreds are mentioned in the Domesday Book. Some of them are named after spots remote from villages lying in the middle of waste land; and one may look upon such a hundred as consisting of a ring of vills or parishes having a large area of common grazing land in the middle of which was a convenient meeting place. Others take their names from larger villages which had been growing into market towns. A meeting place in the midst of waste land proved to be less convenient than a meeting place in a large village, and undoubtedly many of the old market towns originated in this way. It has been

[1] For although alterations were made to some 6,000 parishes, the changes were in most cases very small.

[2] Sometimes believed, at least in some cases, to have comprised roughly a hundred families.

suggested that when the hundreds take their names from waste land it was a common practice for the men of the townships to meet there and sort out their cattle just as is done at the present day at the spring round-up in the great pastoral countries of the newer lands of the world. Disputes were settled by the hundred court, and hence the association of the hundred court later with market towns. The areas of the hundreds became irregular in just the same way as did the areas of the parishes, and gradually the hundred as a unit became less and less important, and local administration was based on the parish and on the county. After the Napoleonic Wars problems arose which were beyond the powers of parishes to solve, and a new unit came into existence which was the Poor Law Union created by the Act of 1834. They were devised in a haphazard way regardless of geographical conditions, with the result that in less than a hundred years they have entirely disappeared. Their place has now been taken by rural districts.

The geographical counties of England are also of very early origin.[1] The majority go back to the time of the Saxons and a large number at any rate were in existence at the time of King Alfred. The counties south of the Thames, broadly speaking, correspond to old kingdoms. Thus in the south-east of England the Anglo-Saxon Kingdom of Kent (Cantii) occupied an area roughly conterminous with Kent. It is to be observed that the areas of these old counties are natural geographical units, and their boundaries are natural geographical features. The frontiers particularly used were the sea, a river, a line of hills—such as the chalk scarp—a tract of dense almost impenetrable woodland or marshland, or an area of barren heath. Thus Kent stretched to the sea and the river on the north, to the sea on the east and to the south as far as the great impenetrable mass of woodland which then occupied the Weald. It must be remembered of these natural barriers that the woodlands have disappeared, even the areas of barren heathland have been largely utilised. Another example is afforded by Sussex, which represents the territory of downland held by the South Saxons (Regni) and which was cut off by the woodland of the Weald from the rest of England. As the woods of the Weald were gradually cleared and settled so that territory was divided between Kent and Sussex. Norfolk and Suffolk form an interesting example of a natural region, occupied in pre-Roman days by the Iceni. It was bounded by the sea on the north and on the east; by the marshland of the Fens on the west; by the thick forests, which must have covered the London Clay lowlands of Essex, on the south. The only landward entry into this region was the narrow belt of

[1] The 52 ancient or geographical counties of England and Wales should not be confused with the 62 administrative counties which themselves exclude the 83 county boroughs or towns with the status of a county.

chalk downland stretching away to the south-west.[1] When the territory of the Iceni was invaded and settled by the East Anglians they found the area rather a large one and divided it into the North Folk and the South Folk—hence the modern counties of Norfolk and Suffolk.

Turning to the Midland counties of England, it must be remembered that the lowlands there were at a much later date occupied by dense damp oakwood forest which, as we have just seen, was gradually cleared and occupied by settlers, in the first instance in clearings in the forest. It would seem that the Midlands of England were arbitrarily divided into shires or counties in the tenth century

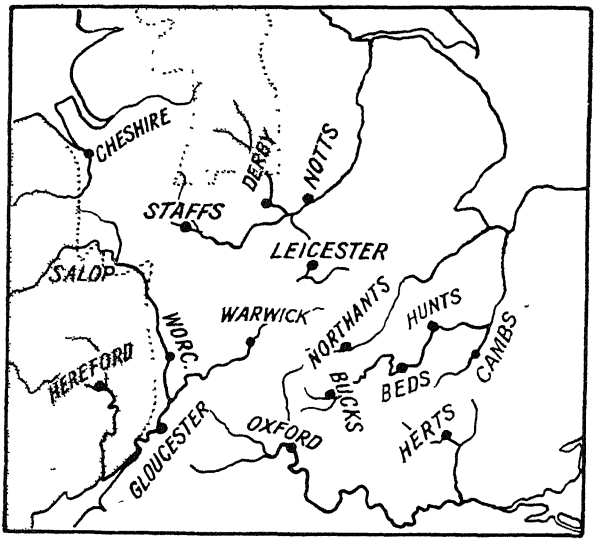


FIG. 248.—Map showing the Midland "shires" or counties of England grouped about the county town, in each case on a navigable river (after C. B. Fawcett)

in the course of the wars between Wessex and the Danes. The method followed seems to have been that certain leading settlements or military strongholds, such as a Danish borough,[2] were chosen as capitals of the shires, and around these were grouped such areas as at that time could conveniently be administered. Thus the Midland shires of England are not the natural geographical units that the southern and eastern counties are. One notices how many of these Midland shires are still named after the principal town. The very names of the old southern and eastern county kingdoms

[1] Along which was the Icknield Way (cf. Ic(k)eni Way, a possible, but unproved derivation) crossed by a succession of dykes or protective earthworks.

[2] The majority on navigable rivers, emphasising the importance of river transport in lowland, still largely forested.

do not need the addition of the word shire, and the name of the county town often bears little or no connection with that of the name of the county, whereas in the Midlands of England we have Bedford, Bedfordshire; Northampton, Northamptonshire; Oxford, Oxfordshire, Warwick, Warwickshire; and so on. It is very interesting to notice how many of these artificially arranged Midland shires are still awkward administrative units, and present difficulties in

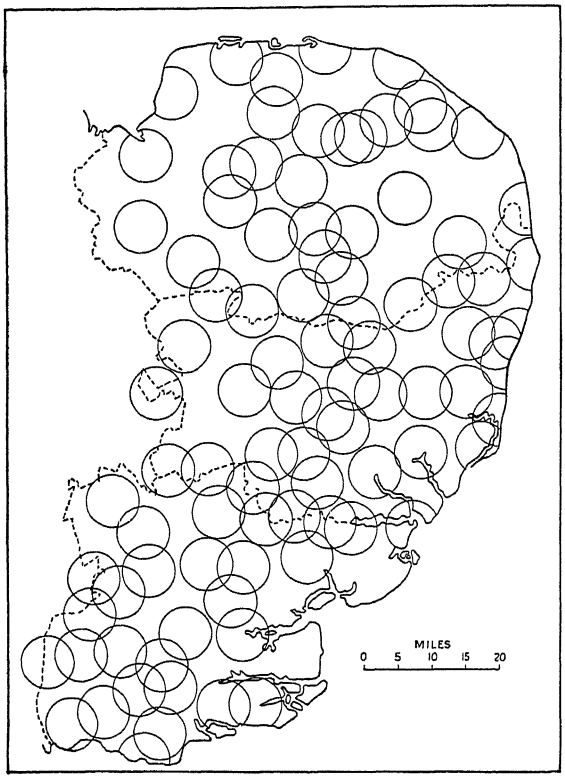


FIG. 249.—The medieval market towns of East Anglia
Showing each with an arbitrary limit of 4 miles radius (after R. E. Dickinson)

administration even to the present day which are not found in those counties based on the natural geographical units of the old kingdoms.[1]

Returning now to the development of settlements, we may take first of all purely rural areas: that is areas which have re-

[1] An immense amount of information is to be gained by a study of place-names Many county volumes have been published by the Place Name Society, and a convenient general guide is *The Oxford Dictionary of English Place-Names*, by E. Ekwall (Oxford, 1940, 2nd. Ed.).

mained rural to the present day. If one looks upon a village as a convenient point of settlement from which the land of the surrounding vill was cultivated then one gets the idea of the primitive village as an essentially agricultural settlement. The first requirement of the people would obviously be a market centre to serve a small collection of vills, where they could exchange their commodities with one another, could sell the surplus that they had, and buy

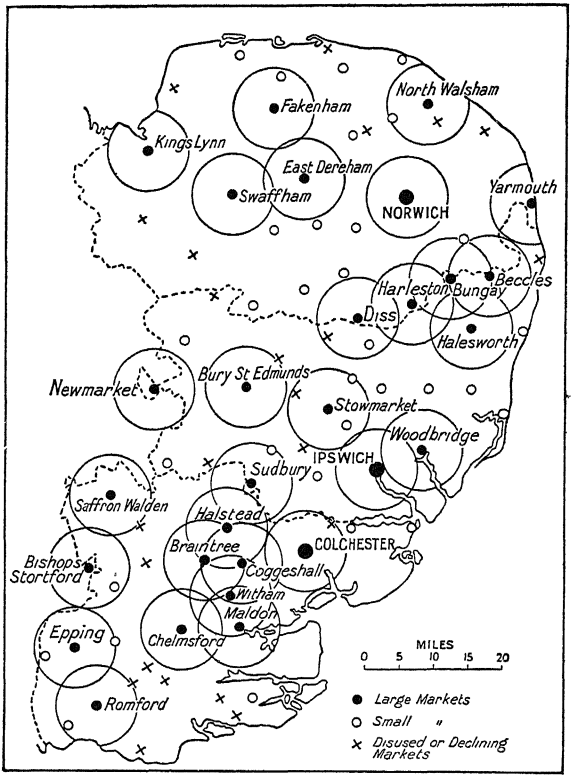


FIG. 250.—The market towns of East Anglia, about 1834
Showing each with a limit of 6 miles radius (after R. E. Dickinson)

such of the simple necessities from the outside world as the requirements of early days demanded. But there was already an organisation which required the federation of eight or a dozen vills and this was the hundred. So it is often the case that one of the larger villages became the market town or centre of the commercial life of a hundred. It is an obvious step from this to the same town becoming the administrative centre of the hundred, *e.g.* for purposes of the administration of the law. In other cases the

administrative function may have preceded the development of a town as a market or commercial centre.

The market towns of medieval England were closely spaced. The visit to the market town had to be made on foot, or if a carriage or other conveyance were available the condition of the tracks or roads of the countryside was so execrable that the radius served by a market town was not very appreciably increased. Although the use of rivers may have been important in appropriate cases it is clear that in the more settled rural parts of England between 7 and 10 miles was regarded as the proper distance between marketing centres. Indeed, there is an old law still in existence which makes it illegal to establish a market within $6\frac{2}{3}$ miles of an existing legal market. In an interesting study of the distribution and functions of the urban settlements of East Anglia, R. E. Dickinson[1] suggested that the maximum range of influence of the medieval market was about 6 miles, and he drew a map to show an abitrary market area of 6 miles radius to each medieval town in East Anglia. It is remarkable how long this primitive arrangement of marketing and administrative centres remained; and it was not until about the middle of the eighteenth century that changes occurred. The gradual development of road transport after about 1780 in particular, resulted in the concentration of marketing in fewer towns due to the increased marketing radius which was possible. In the main, nodality, with ease of communications in different directions, was the factor which determined the survival of the fittest. In the early part of the nineteenth century it was possible to classify the market towns of the rural countryside into three groups: large, small, and disused or rapidly declining. This was the state of affairs in 1834 when the Poor Law Unions were brought into existence, and the market towns were constituted headquarters of the Poor Law Union districts and the seat of the Board of Guardians. But the bad designing of the unions soon became apparent; for there followed the great development in railways and the macadamisation of roads. People could easily go 8 or 10 miles to or from their market town far more easily than their forefathers two or three generations ago could travel half that distance. Roughly speaking, every alternate market town decayed, and the prosperity of the intervening ones increased. The remaining market towns were given what may be described as a new lease of life when they became the centres of the new rural districts. In the separate County parts of *The Land of Britain,* the Final Report of the Land Utilisation Survey, the distribution and functions of the agricultural markets are considered as they were in the 1930's. Broadly speaking, live stock markets, for example in the south-west, are closely spaced whereas grain and produce markets, as

[1] *Geography,* XVII, March 1932, 19–31; see also "The Town Plans of East Anglia," *Geography,* XIX 1934, 37–50.

in East Anglia, draw from a much wider area. The reasons are obvious.

The early progress of towns in what are now industrial areas was, of course, similar. Early industrialisation seems to have been fostered by one or two main causes: (*a*) the inhabitants of the town tried to utilise for some manufacture raw materials supplied to them by the visitors to the market; the rise of the woollen industry using the wool sold by local farmers is thus characteristic of Norwich and certain towns of East Anglia; (*b*) the inhabitants found that they could supply the needs of some of their neighbouring agriculturalists by goods made in their own centre. It would seem that the early trade in horseshoes and other small iron objects in Birmingham started in this way—with a supply to farmers in the local districts; the iron ore being available near at hand and charcoal for smelting it from the neighbouring forests. The cutlery industry of Sheffield may be cited as a similar instance. Natural advantages and a near-at-hand market for the produce were responsible for the inception of the industry. Thus, leaving on one side altogether the ports, a number of small manufacturing centres sprang up all over England. The Industrial Revolution and the flight of the industries to the coalfields resulted in the disappearance of many of these small industrial centres and in the immense development of others.

Here we may break off for a moment and consider what are the essential functions of a town or an urban settlement. Grouped into broad categories the functions may be described as follows:—

(*a*) Commercial.
(*b*) Administrative.
(*c*) Industrial.
(*d*) Social.
(*e*) Residential.

A study of the urban settlements of the British Isles shows that the relative importance of these functions varies from town to town. Sometimes the one may be so important as to overshadow all the others. There are reasons why the study of the functions of a town are of the utmost importance, particularly at the present day. One of these reasons is that it is perfectly clear that town planning must be varied not only according to the site which is available, but according to the functions of the town concerned. Let us attempt, therefore, to analyse in slightly more detail each function.

(*a*) *Commercial.*—This function is concerned primarily with the buying and selling of goods. The larger the town the greater the cleavage or difference between wholesale and retail. In all the larger towns there is usually a definite commercial centre. It may be represented in the large market town of a rural county by the

[*Photo: L. D. Stamp*

FIG. 251.—Carnarvon Castle, North Wales

A reminder that the administrative function of an urban settlement is a very old one

cattle market and its surrounds—the storehouses of the corn chandlers and of the vendors of agricultural implements. In a town of a different type it is represented by the closely spaced streets of large warehouses. But in either case the wholesale commercial centre is divorced from the retail shopping area. The growth of a town as a wholesale commercial centre depends above everything else on its nodality and its transport facilities. Under this heading comes naturally the relationship between the commercial centres of the larger towns and the railway and road systems on the one hand, and the facilities for the import of goods on the other. Thus in the larger ports we find the warehouses, representing the commercial centre, grouped near or around the docks.

(*b*) *Administrative.*—For purposes of administration, particularly for administration applying to the whole county, undoubtedly one of the factors of greatest importance is ease of accessibility to all parts of the area concerned from the centre chosen. Quite frequently the county town has ceased to be ideal from this point of view—especially when it is essential to retain vital and immediate contact with some large centre on the borders of the county. Thus the county offices of both Lanarkshire and Dumbarton are in Glasgow. For many purposes Kingston-on-Thames and not Guildford is the county town of Surrey. Much of the business of the county of Essex is conducted from its London office.

(*c*) *Industrial.*—It is important to realise how many of our larger towns are essentially industrial, whilst they are neither commercial nor administrative in an important sense. The reverse is also true. Manchester and Leeds are primarily the commercial and to some extent administrative centres, as well as in some degree social centres, of a manufacturing area in each case, rather than being primarily industrial. We have considered elsewhere in this book the requirements of industrial centres, and these points need not be reiterated: but just as the commercial and the administrative offices of a large town are frequently collected together in definite areas, so also—even more markedly—are the industrial works. Provided the essential requirements of easy receipt of raw material and easy despatch of finished articles are satisfied then the town planner can do much to direct industrial development round an existing town in those ways which will best serve the whole community.

(*d*) *Social.*—The social functions of an urban settlement are not always fully realised or given their proper importance. Women form more than half the population of the British Isles, and it is calculated that over three-quarters of the money passed over counters in retail stores is passed over by women. In other words, women do the shopping. Yet how many women pay a visit to a town with the purely utilitarian motive of shopping and nothing

else? This question might have a double question mark after it. For is it not true to say that the choice of the town and the choice of the route are not infrequently determined by (*a*) the attractive nature of the displays in the shop windows; (*b*) the possibility of a lunch in a pleasant restaurant with music, and (*c*) a visit to a cinema where light and life—real and unreal—afford a relaxation from the daily round and common task? In the larger towns or for longer journeys, such as a trip to London, there may be the added attraction of the theatre. The hotel and the club must be near at hand. It is particularly in the evening that the town exercises its social influence over men and women together. This conjunction of the social services is of the utmost importance, because in town planning one cannot divorce the shopping centre from the centres of amusement such as we have described. What is the quintessence of the importance of the West End of London and of other cities which boast a West End? Or of Broadway and Fifth Avenue in New York? In certain towns another factor of importance comes in and that is the influence of the church. No one who has lived in a smaller cathedral city can fail to appreciate the importance of this factor and its influence. In some areas schools and colleges exert a somewhat comparable influence. It is often forgotten that there are large numbers of towns in the British Isles where the social influence is paramount, and where the fostering of the social influences becomes the main industry of the town. This is, of course, the case with seaside resorts and with inland spas. With all her richness in scenic beauty and historic remains Britain has not realised the full possibilities of what has now come to be called the tourist traffic or "tourism." For example, how many British seaside resorts have so far developed their attractions in the winter months that one may unhesitatingly go for a week-end being assured of a lively and sustained period of relaxation from daily business? Here the modern generation, not unreasonably, demands things on a large and lavish scale. Nothing could be more miserable than the seaside resort with three-quarters, perhaps all, of its places of amusement closed for the winter; and nothing could be more attractive than a fine pavilion—well lit, with music, food, and a view of the sea—in the winter months. In the preceding chapters of this book, it will be found that a number of quite large towns have scarcely been mentioned. They have little or no concern with industry, they are not ports nor commercial nor administrative centres. They are in fact essentially social-residential cities and towns. A leading member is Bournemouth—the youngest large town in Britain; others include Harrogate, Bath, Buxton (spas); Scarborough, Cromer, Margate, Eastbourne, Torquay, Newquay, Llandudno, Blackpool, and Douglas (I. of Man) (seaside resorts). A pioneer study of their evolution was made by E. W. Gilbert

(*Scot. Geog. Mag.*, LV, 1939, 16–35), and he has since analysed the development of Brighton in detail (*Geog. Jour.*, CXIV, 1949, 30–53).

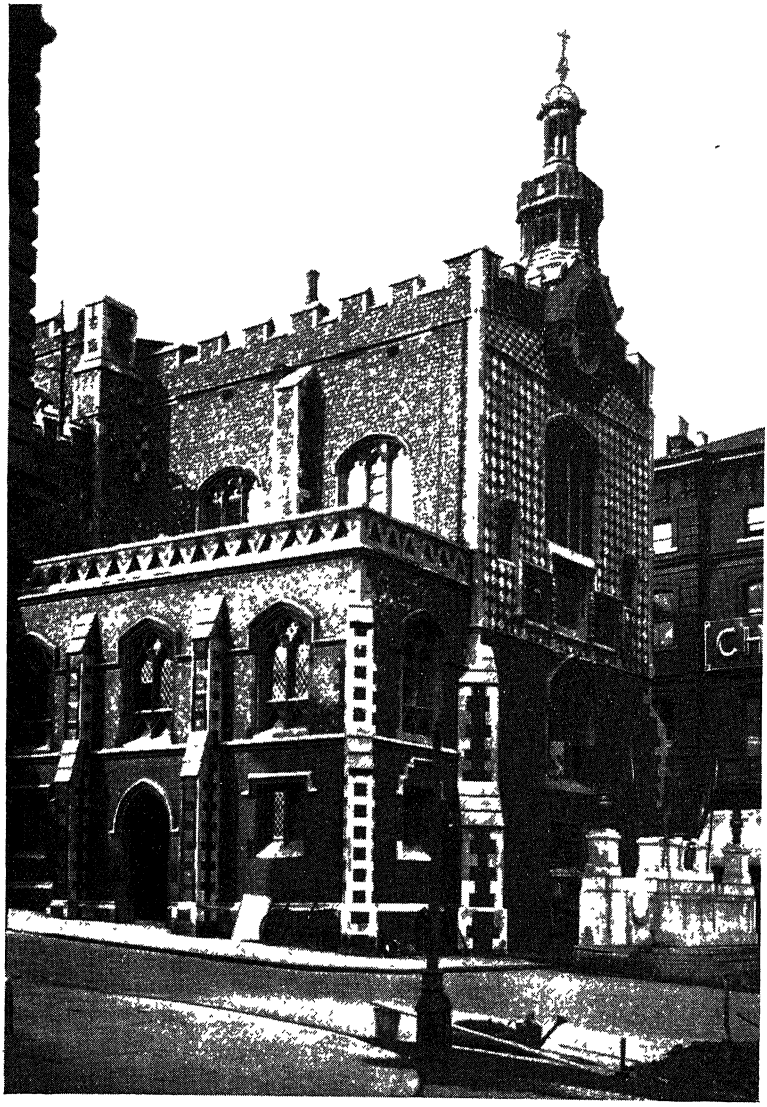
(*e*) *Residential.*—There are some towns which are mainly residential. They are either dormitories for the large cities such, for example, as many of the smaller towns in a ring round London, or they may be the residential town for an industrial area, as Newcastle-under-Lyme is for the smoky Pottery towns of the North Staffordshire coalfield. But a fact, again too often forgotten at the present day, is that there are very few areas which can be purely residential in this sense. They must either have absolutely first-class facilities for communication with the larger centres, or they must develop their own social life. Expensive housing estate schemes and garden city suburb schemes have proved failures for this very reason; and here arises a big question which the Britisher has not yet decided. His choice at present is between the semi-detached villa with the little strip of garden where he may amuse himself in the evenings, but from which he has to face daily his half-hour's or his hour's journey to and from his business, and the flat in a block of luxury flats in a large building where he has at hand the social attractions of the city, including the public parks with their beds of flowers, probably so superior to anything that he could have produced in his own little garden had he been a dweller in the suburbs.

This disquisition on the functions of urban settlements has been rather a lengthy one; but it is a subject to which more and more thought is being given in England. For a true interpretation of trends is a necessary prelude to a successful planning for the future.

It is true that a town or city in the fullest sense of the term has all its functions fully developed. A few years ago the late Professor C. B. Fawcett, in a suggestive little book, outlined a scheme for the division of England and Wales into provinces, each province, of course, with a provincial capital. It is clear that he had in mind the necessity of a provincial capital having fully developed all the functions above outlined for towns.

When Fawcett wrote, it seemed unlikely that Britain would ever be divided into provinces and such was the comment made by us in the first edition of this book. The outbreak of the Second World War and the imminent danger of invasion led to the division of the country into Civil Defence Regions each with a Commissioner representing the Central Government and with headquarters in a centrally placed city or regional capital. The regions were quickly adopted by many government departments for their own purposes, with this remarkable difference—that each department, and frequently individual divisions within a department, decided for itself the number, boundaries, and capitals of its regions. When the war came to an end the regions or provinces were firmly established

and have remained, and civil servants allotted by their departments to the regions carry in many cases the title "Provincial"—for



[Photo: L. D. Stamp

FIG. 252.—The ancient Guildhall of the City of Norwich
Built of the traditional local materials—faced flints

example the Provincial Land Commissioner of the Ministry of Agriculture—or in other cases "Regional" such as the Regional

Planning Officer. Most departments recognise about 9 or 10 provinces for England; Wales forms at least one other, whilst Scotland for many purposes is divided into four. A comparative view of the many different regional divisions adopted up to the time he wrote has been given by E. W. Gilbert (*Geog. Jour.*, XCIV, 1939, 29–44).

Some of the Provinces suggest themselves with their Provincial capitals, others are far from satisfactory. For example some parts of the South-Western Province are more difficult to reach from Bristol, the Provincial Capital, than from London. Similarly although East Anglia is a natural province, its obvious capital Norwich is less conveniently situated in many respects than Cambridge, which several ministries use for the purpose. Cambridge has the advantage of easier and quicker access from London, yet Norwich has the natural attributes of a provincial capital. Centrally situated on the East Anglian plateau, it is even so a port. Its large cattle, sheep, and pig markets point it out as the natural capital of a predominantly agricultural area; and it is, of course, the administrative centre of the large county of Norfolk. It has developed manufactures of two main types: the food industries utilising the produce of the farmers of the region; and side by side with them the manufacture of agricultural implements and such things as wire netting which are required in quantity by a farming community. In other cases its industries have undergone an interesting process of evolution. When the woollen and worsted industries departed to the coalfields, manufacture of boots and shoes—of recent years fancy shoes of women's use—was deliberately introduced. The totality of its civic and religious life, the intense local patriotism, the extent and variety of its shopping centres, and its amusement facilities leave no doubt as to the importance of the city as a social centre.

The study of towns and their zones of influence or "urban hinterlands" has become of great practical importance in connection with physical planning and reconstruction following the Second World War. In a pioneer study of Leeds and Bradford some years ago, Professor R. E. Dickinson showed the complexity of the problem—that there might be tracts of country relying on one centre for certain purposes, on another for other purposes. In the Land Utilisation Survey's Report on Hampshire, F. H. W. Green paid special attention to public road services in determining urban hinterlands or "umlands" and developed this idea when he became Maps Officer to the Ministry of Town and Country Planning (a Ministry created in 1943, but merged into Housing and Local Government in 1951). On the basis of bus services, he demarcated the whole of England and Wales into "urban hinterlands." The main criticism of the method is that the picture can be quickly

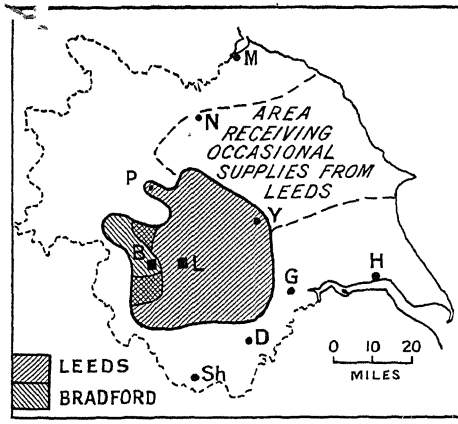


FIG. 253.—The zones of influence of Leeds and Bradford as distributing centres[1]

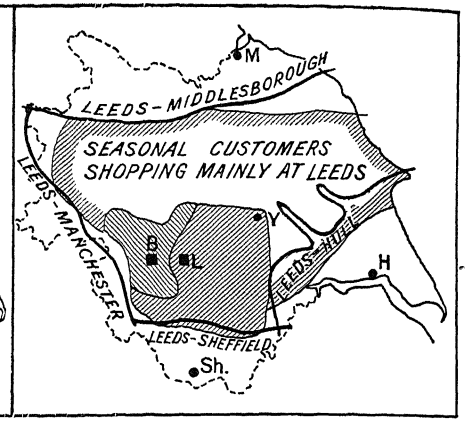


FIG. 254.—The zones of influence of Leeds and Bradford as market or shopping centres

The heavy lines mark lines of equal accessibility or time by train of the two towns mentioned in each case

and radically changed by simple alteration of the bus services provided.[2]

A practical attempt to overcome the disadvantages of a long journey to work was initiated by the Government after the Second World War in two ways. One was by encouraging industry and consequent development in some of the smaller towns, the other was by the deliberate creation of a dozen new towns—a ring around London in Crawley, Bracknell, Stevenage, Hemel Hempstead, Harlow and Basildon, at Newtown Aycliffe and Peterlee in Durham, Cwmbran in South Wales, and West Kilbride in Fifeshire. These were planned *ab initio* on what are usually called garden city lines with a spacious layout and a low density both of houses and people per square mile. The new towns thus take part at least of their inspiration from the pioneer garden cities of Letchworth and Welwyn. They differ from garden suburbs (such as Hampstead Garden City and Wythenshawe, Manchester) which are mainly residential. Elsewhere trading estates (*i.e.* estates where factory buildings are constructed for letting) have been used as nuclei of new or extended urban developments—as at Trafford Park (Manchester), which dates from 1902, Team Valley (Tyneside), and Slough (London), which were developments mainly of the inter-war years.

[1] "The Regional Functions and Zones of Influence of Leeds and Bradford," *Geography*, XV, 1930, 548–557. Here Leeds is the regional capital, Bradford the great manufacturing city.

[2] F. H. W. Green, "Urban Hinterland in England and Wales," *Geog. Jour.* CXVI. 1950, 64–88. A more general treatment is that given by A. E. Smailes, "The Urban Mesh of England and Wales," *Transactions and Papers of the Institute of British Geographers*, 1946.

Side by side with such planned urban development has grown the national desire to preserve the best of the past, whether historic buildings (many now owned by the independent National Trust, or "scheduled" as such by the Government) or the countryside—hence the activities of such bodies as the Council for the Preservation of Rural England (C.P.R.E.) and the creation of National Parks under the official National Parks Commission

Modern developments in town and country planning have also

[Aerofilms Library, London

FIG. 255.—Air view of the new town of Peterlee, Co. Durham, 1953

rendered it imperative to study more precisely the problems of rural population—including rural depopulation. Official figures show rather more than 80 per cent. of the British population as "urban," rather less than 20 per cent. "rural." The rural population as officially defined is that living in Rural Districts which may include quite large towns (*e.g.* Didcot, the railway town of Berkshire). The truly rural population living in isolated farms or cottages, hamlets, and villages does not exceed about 10 per cent. of the total. Here

agricultural mechanisation may well lead to a further decrease in the labour force required, increased mobility by bicycle, motor-bicycle and car as well as by buses leads to a concentration of retail supply sources in the towns, the smaller families now usual may result in such small numbers of children in the cottages that schools can no longer be kept open. Indeed the whole social structure of country life is threatened. The suggestion the writer made a few years ago to distinguish in the rural populations three groups is now commonly used.[1] These groups are:—

(*a*) The Primary Rural Population of farmers, farm workers, and their families,
(*b*) The Secondary Rural Population of those who exist to provide essential services to the first group,
(*c*) The Adventitious Rural Population living in the county by choice.

It has been found that group (*c*) may be entirely absent in country valuable agriculturally, but less attractive residentially (such as large parts of the Fens), and that in such cases (*a*) and (*b*) are in the proportion of 2:1. In most cases it is found that a vigorous rural life—an active parish council, live social, religious, and educational institutions—often depends largely on the adventitious population, including retired people, hence its importance.

It has long been recognised that the British census figures gave a quite inadequate measure of the relative size and importance of the larger centres of population because the figures refer to the areas defined by local government boundaries. Actually the densely populated areas are contiguous and form continuous urban areas. One of the best known examples of this, of course, is that of Manchester and Salford. Thus the term conurbation—suggested by the late Sir Patrick Geddes—has come to be widely adopted. Professor Fawcett defined a "conurbation" as "an area occupied by a continuous series of dwellings, factories, and other buildings, harbours, and docks, urban parks and playing fields, etc., which are not separated from each other by rural land; though in many cases in this country such an urban area includes enclaves of rural land which is still in agricultural occupation." On this basis there were at the time of the 1931 Census no less than seven large conurbations in Great Britain, six of which had more than a million people; and there were also thirty other towns with more than 100,000 people.[2] It was found that 40 per cent. of the total population of

[1] *The Land of Britain, Its Use and Misuse.* First Edition, p. 448.
[2] Where the urban areas are not continuous the term "town cluster" may be used and is appropriate for the Black Country, or the ring of towns around Manchester mentioned below, or the West Riding woollen towns outside Leeds and Bradford.

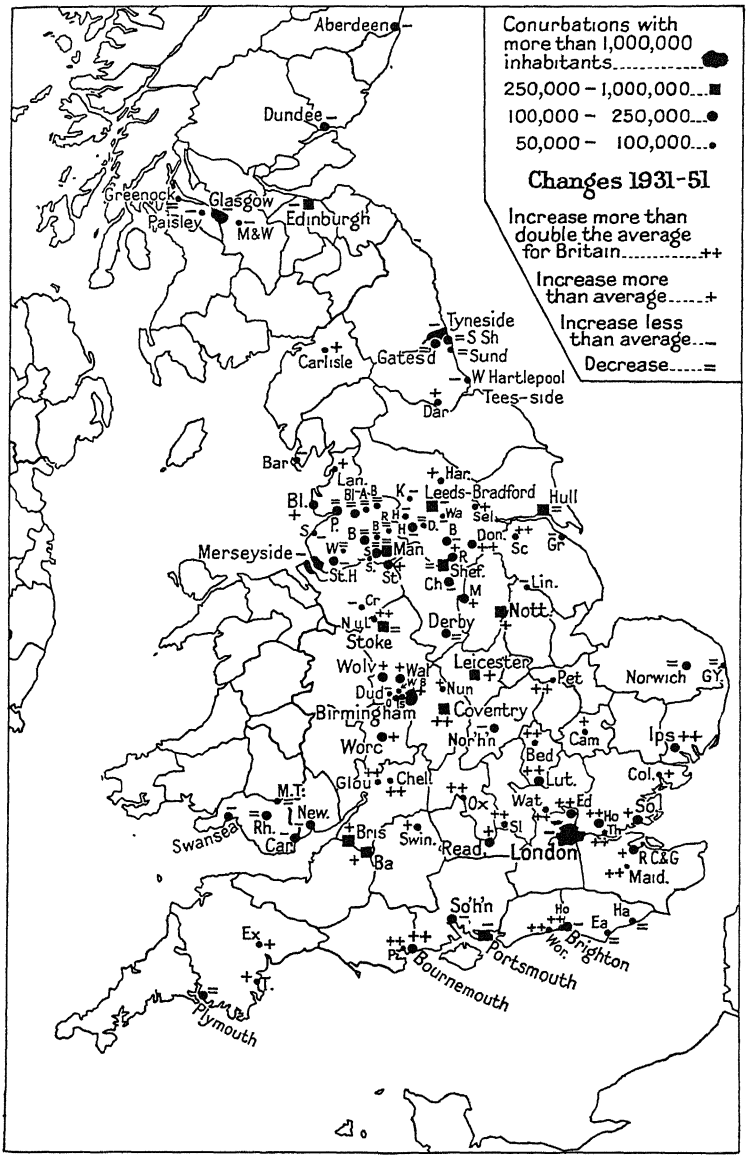


FIG. 256.—The larger towns of Britain (all with more than 50,000 inhabitants are marked), and their population changes, 1931–1951

Britain was living in the seven "million cities" or conurbations—half the total urban population. The Census of 1951 gave official recognition to each of these conurbations which were defined in

terms of complete local government areas. The seven conurbations thus officially recognised are as follows:—

(1) Greater London—with an aggregate population of 8,346,137 in 1951, and covering 721 square miles. Separate consideration is given below to London.

(2) South-East Lancashire or Greater Manchester—with the continuous urban area of Manchester and Salford in the centre, and a number of smaller urban districts closely joined therewith, thus giving an inner ring with more than 1 million inhabitants. Round this, at a distance of from 12 to 18 miles from the central point, is what may be called the Manchester ring: the towns of Bolton, Bury, Rochdale, Oldham, Stockport, etc., all being linked to the central core by regular bands of urban character. The total population in 1951 was 2,421,011 over an area of 379 square miles.

(3) The West Midlands or Greater Birmingham and the Black Country.—The city of Birmingham contains about half the total urban population in this total area of 268 square miles and 2,236,723 people.

(4) The West Yorkshire conurbation, of which Leeds and Bradford are the two largest members, and which includes most of the woollen towns of the West Yorkshire coalfield has a total area of 480 square miles and 1,692,190 people.

(5) Merseyside—including Liverpool, with two-thirds of the total population, and Birkenhead and Wallasey on the opposite side of the Mersey—covers 148 square miles and had 1,382,244 people in 1951.

(6) Tyneside, of which the natural centre—Newcastle—contains about a quarter of the total population, covers 90 square miles, and has 835,332 people.

The Industrial Regions of Britain.—In a previous chapter we have considered the agricultural regions of Great Britain, and it has already been noted that many of the market towns within those regions developed, for various reasons, manufacturing industries. Leaving on one side the ports and the regions accessible from the coast, we have noticed that the early industries tended to be either those using the local raw materials of agricultural origin or industries which were primarily concerned with supplying the urgent needs of the rural population of the neighbourhood, though which in turn tended to depend upon readily available supplies of local raw materials. We have seen also that the coming of the Industrial Revolution entirely altered the distribution of population in Britain. There has thus arisen in Britain another series of regions—the great industrial regions—which can be looked on as superimposed upon the agricultural regions and to a large extent independent of them.

In this book we have considered each of the leading industries of the British Isles separately and not according to the industrial regions. The reader will find an account of the regional geography of Britain as it was prior to the Second World War in that valuable volume edited by Professor A. G. Ogilvie, entitled "Great Britain: Essays in Regional Geography."[1] Many of the larger industrial regions were investigated in the inter-war years by the Universities of the country at the request of the Board of Trade, and a series of "Industrial Surveys" was published. Many of the industrial areas suffered severely from bombing in 1940–1945 and the elaborate plans prepared and published as a prelude and guide to rebuilding were usually based on careful factual survey and so contain a vast amount of geographical material. Later, to meet the requirements of the Town and Country Planning Act of 1947 Development Plans have been drawn up, often with elaborate surveys. In order to facilitate the work of those who may be interested in one particular area the following list of the leading industrial regions is given:—

I. *North-eastern England or Northumbria (including Tees-side and Tees-mouth).*
II. *The North-western Industrial Area.*
III. *The Industrial Region of Lancashire and North Cheshire.*
IV. *The Potteries.*
V. *The West Yorkshire or West Riding Region.*
VI. *The South Yorkshire or Sheffield Region.*
VII. *The Nottingham Area.*
VIII. *The Leicester Area.*
IX. *The Warwickshire Region.*
X. *Birmingham and the Black Country.*
XI. *South Wales.*
XII. *London and the South-east.*
XIII. *The Midland Valley of Scotland.*

[1] Cambridge University Press. It was prepared for the International Geographical Congress, which met in Britain in 1928. A second edition appeared in 1930 and a reprint in 1951.

CHAPTER XXVI

LONDON

What is London? Before attempting any description of London and its activities, it is necessary to attempt to define what the name "London" connotes. For at least half a dozen different boundaries are in common use, each enclosing a tract which, for specific purposes, is considered as "London." Two of these are precisely defined administrative units—the City of London which is the original heart of the whole, and the County of London. The County was created by the Local Government Act of 1888 and was carved out by taking parts of the counties of Kent, Surrey, Middlesex, and Essex. Despite its area of 117 square miles the County proved inadequate before many years had passed to contain the population whose life and work were centred in London. The loose designation "Greater London," came to include the City, the County, and a variable outer ring. Specific definitions of Greater London were used for different purposes, such as the Metropolitan Police area, the London Postal area, the London Telecommunications area and the London Traffic area (served by the London Passenger Transport Board when that body was set up to co-ordinate tram, bus, and underground rail services). The population of "Greater London" given by the Census figures for 1921 and 1931 refers to the Metropolitan Police Area. For the purposes of the 1951 Census Greater London or the London conurbation was precisely defined in terms of administrative units and covers, with minor modifications, the same area—a total of 721 square miles. It should be noted that when Sir Patrick Abercrombie prepared the Greater London Plan, 1944, to cover post-war redevelopment and expansion a much wider area was taken into consideration.

The City.—The smallest unit which may be designated "London" is the City of London, commonly called the City, and which coincides roughly with Roman London or with medieval walled London, though overlapping both to some extent. The City is only a little over a square mile in area (678 acres) and, lying wholly to the north of the river, includes the two hills separated by the long since obscured Walbrook. To the west the City extends beyond the medieval Lud Gate and the valley, where once the Hol-bourne flowed into its estuary the "Fleet," as far as Temple Bar. Here, until 1878, a bar in the form of an archway across Fleet Street

actually existed to mark the limit of the City of London, and at this point it is still the custom of the Lord Mayor to present the sword of the City to the ruling sovereign on his entry. The City is still the hub about which the great wheel revolves. London became a world exchange for almost every commodity as well as the greatest centre of banking and insurance, and as such earned the proud title of the commercial capital of the world. The City is still the heart of this commercial London, but it no longer has the monopoly that it had until the First World War. For every important business house in the world has offices or representatives in London and, since a deliberate policy of limitation of height of buildings prevented the building of skyscrapers, commercial London has had to expand laterally and so invaded the formerly residential or "social" areas of Westminster and the West End. Great office buildings of the inter-war period, such as Bush House, are outside the City, whilst other office buildings of the same period such as Thames House and Imperial Chemical Building are even farther west than the Houses of Parliament. But the City still has within its bounds the Bank of England ("The Old Lady of Threadneedle Street"—rebuilt in the inter-war years, from within with the exterior unaltered), the Stock Exchange, and the great commodity exchanges as well as the world-famous insurance corporation of Lloyds, the ancient Guildhall, and the official residence of the Lord Mayor (the Mansion House). Parts of the City suffered severely by bombing during the Second World War, especially the section between St. Paul's Cathedral and the Bank. The preservation of St. Paul's itself, almost unscathed, was virtually a miracle.

The ever increasing pressure on space required for office accommodation has naturally resulted in a steadily decreasing residential population. Compared with 128,129 in 1801, by 1931 only 10,996 persons, largely resident caretakers, were recorded as actually living in the City, but nearly half a million came in daily to work in its offices. By 1951, the total had fallen to 5,000. The deserted City on a Sunday morning is a sight not to be forgotten.

The County of London.—The County of London comprises the City of London, Westminster (created a "city" in 1900) and 27 metropolitan boroughs. The four boroughs of Stepney, Poplar, Shoreditch, and Bethnal Green lying to the east of the City coincide roughly with what is popularly designated the "East End." The "East End" is still essentially industrial, and some of the leading industries will be noted later, whilst the southern parts, Stepney and Poplar, include some of the docks of the Port of London. Several of its outstanding features—its rows of small, too frequently squalid, houses, its innumerable little shops—the East End shares

with the majority of industrial towns, but the large alien population is a distinctive feature. Whitechapel, lying within this area, is popularly, and largely correctly, associated with a major part of London's Jewish population; Limehouse with London's "China Town." The East End suffered severely from war-time bombing which destroyed or seriously damaged approximately 20 per cent. of all houses in Britain, thus creating a very serious housing shortage. This led, in London as elsewhere, to a conflict of policies. Any house which could be rendered habitable was patched up; any vacant space might be used for temporary prefabricated homes erected from sections ("pre-fabs") leaving but limited space for imaginative rebuilding on modern lines. One of the best examples of the latter is the Lansbury Estate of Poplar. Elsewhere sheer necessity has led to the building of blocks of flats, despite the strongly held belief among many that the Englishman will always prefer an individual home. Another post-1930 problem has been the influx of political and other refugees from continental Europe, and many areas of London now have large alien populations.

To the immediate west of the City of London is the City of Westminster. Less than 200 years ago it was still a pleasant walk through the fields from London to Westminster, but it has long since been impossible to the ordinary Londoner to distinguish where one begins and the other ends. In Westminster are the Houses of Parliament and that street of government buildings, Whitehall, with its famous, if insignificant, offshoot Downing Street. Westminster merges into and in many respects is part of the "West End." Here the fashionable residential area still clings round the parks and squares, whilst London's great shopping centres lie along the main thoroughfares. But great blocks of flats have largely replaced ducal mansions, shops are invading the quiet residential squares, office buildings are replacing hotels. The West End includes also that curious enclave of somewhat squalid streets, famous for its varied foreign population and its restaurants, known as Soho—a local industrial area largely dependent on the main shopping centres near by. The West End is ill-defined and merges outwards on the west and north into the upper-class residential areas. The East End, the City, and the adjacent boroughs of Holborn and Finsbury, and the West End may be regarded as constituting central London, but to the north and west, within the county, there lies a large area, partly residential, partly industrial (the Metropolitan Boroughs of Paddington, Marylebone, Hampstead, St. Pancras, Islington, Stoke Newington, Hackney, Chelsea, Fulham, and Hammersmith). That part of London lying south of the Thames is largely industrial and commercial in its inner ring, and residential towards its outer margins. Much of the housing—as well as other building—is obsolete or obsolescent and awaits reconstruction.

Greater London.—Greater London comprises the City, the County, and an "outer ring" which lies in the administrative areas of the counties of Middlesex, Hertfordshire, Essex, Kent, and Surrey. The Metropolitan Police area, or Greater London of the 1951 Census, is shown in Figs. 258, 259 and 260. The outer ring coincides with what may be roughly termed the "suburbs" or the outer suburbs. Taking the outer ring as a whole, it may be described as London's dormitory, and a very large proportion of those who

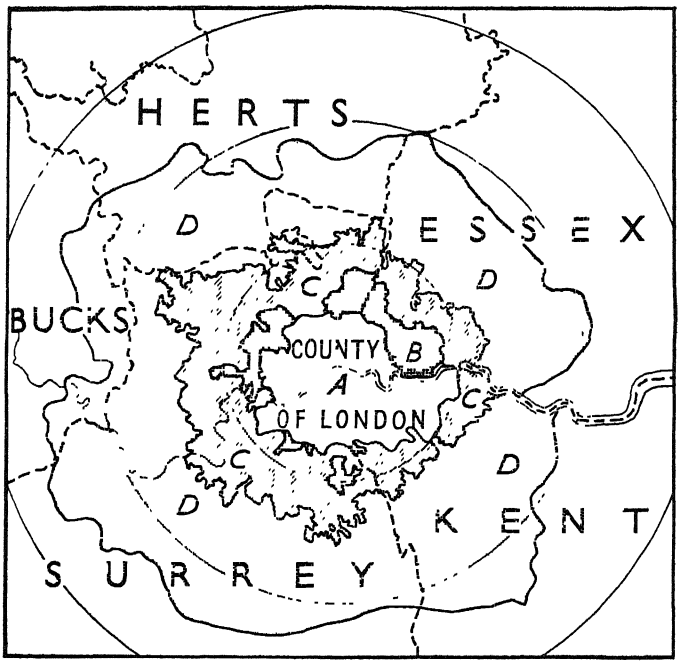


FIG. 257.—London

A=the County of London; B=closely built up, C=suburbs, D=Outer Ring. The circles are described with a radii of 10, 20, and 30 miles from the Bank of England

live therein journey daily to some point within the administrative County of London to earn their daily bread. But there are included within this outer ring areas of a different character:—

(*a*) Some tracts of the outer ring which are administratively outside the County of London are really an integral part of London proper. Thus, the largest of London's docks lie in West Ham, and East Ham, and the industrial district of the East End merges insensibly into West Ham, East Ham, Barking and, more recently, Dagenham. Similarly, on the south side the Erith industrial area is a continuation of that of Woolwich.

(*b*) On the other hand, some centres in the outer ring retain an entity of their own as local centres—for example, Croydon, which is a County Borough, and Epsom.

(*c*) In other tracts, notably in the north-west sector and especially along the main line of the old Great Western Railway

FIG. 258.—The administrative divisions of Greater London, 1951

through Slough, new industrial centres have developed and are expanding rapidly in the heart of the outer ring.

Greater London in another sense (as used, for example, by Abercrombie in the Greater London Plan) embraces an even larger area stretching to the crest of the chalk hills on the north and even beyond them on the south, and is thus equivalent to rather more than the central part of the London Basin. An increasingly large number of those whose business takes them daily to London

take a pride in living "outside the suburbs" and this they are enabled to do by the increased transport facilities. By the 1930's the ever-extending electrified services of the Southern Railway ran out as far as the coast at Hastings and Brighton: on the north the Metropolitan Railway extended beyond Aylesbury, whilst to the

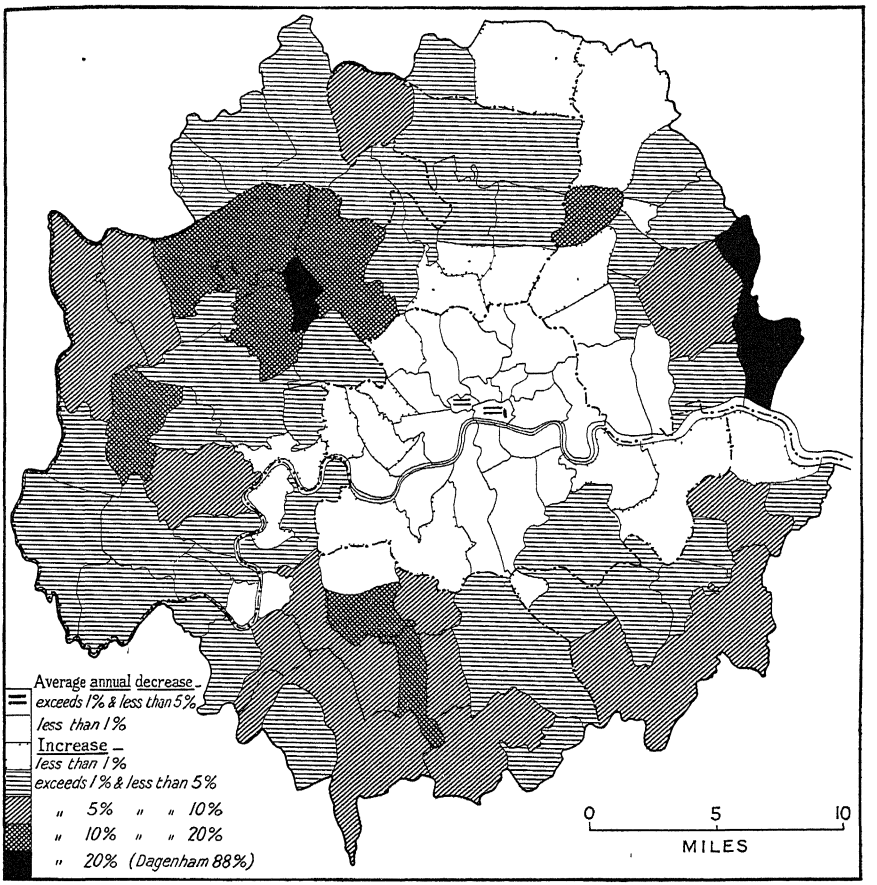


FIG. 259.—Population changes, 1921–1931, in the administrative divisions of Greater London

Showing the decreasing population of the county or inner ring and the increasing population of the outer ring

east the number of season ticket holders to Southend was very large. The ever-extending sprawl of London led not only to an apparently insoluble traffic problem of rush-hour traffic, to a journey to work absorbing two or even three hours of each day, but also to a virtual extinction of any rural country within 20 or 25 miles of the centre. This has resulted in conscious planning to limit the growth of

London by imposing a green belt, wherein building is prohibited or severely limited, by offering inducements to manufacturers to expand elsewhere, and by building new towns to serve as self-contained "overspills" for London. Most of the towns on this

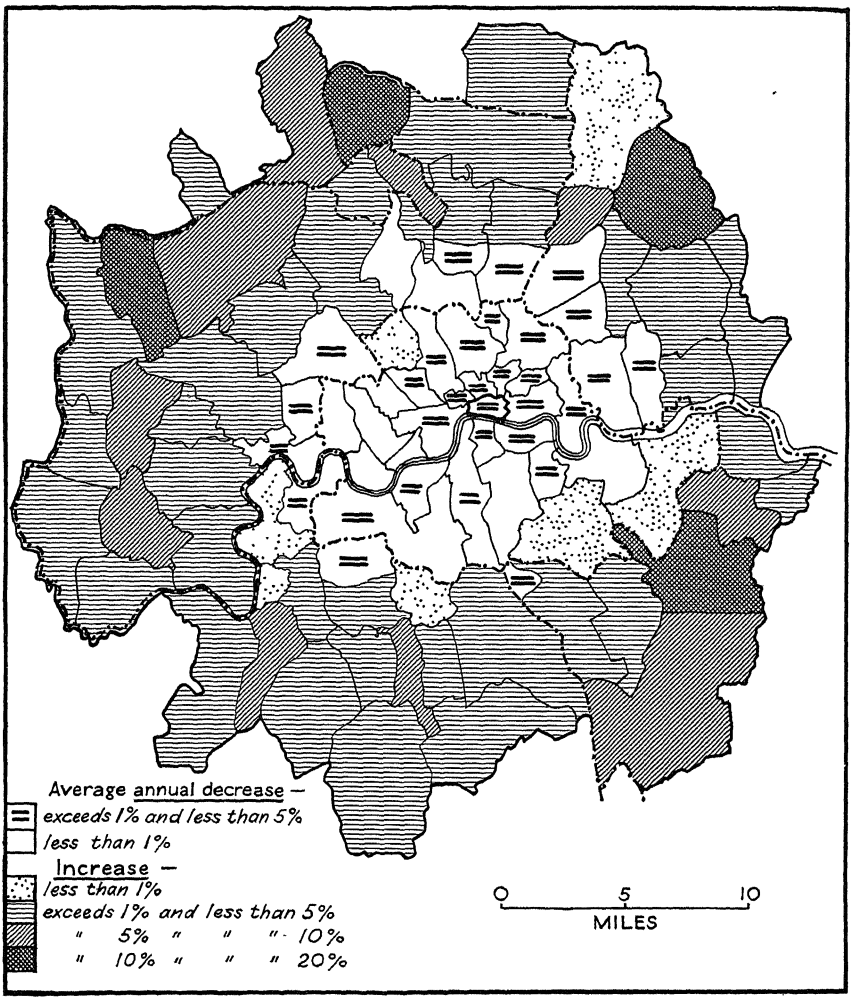
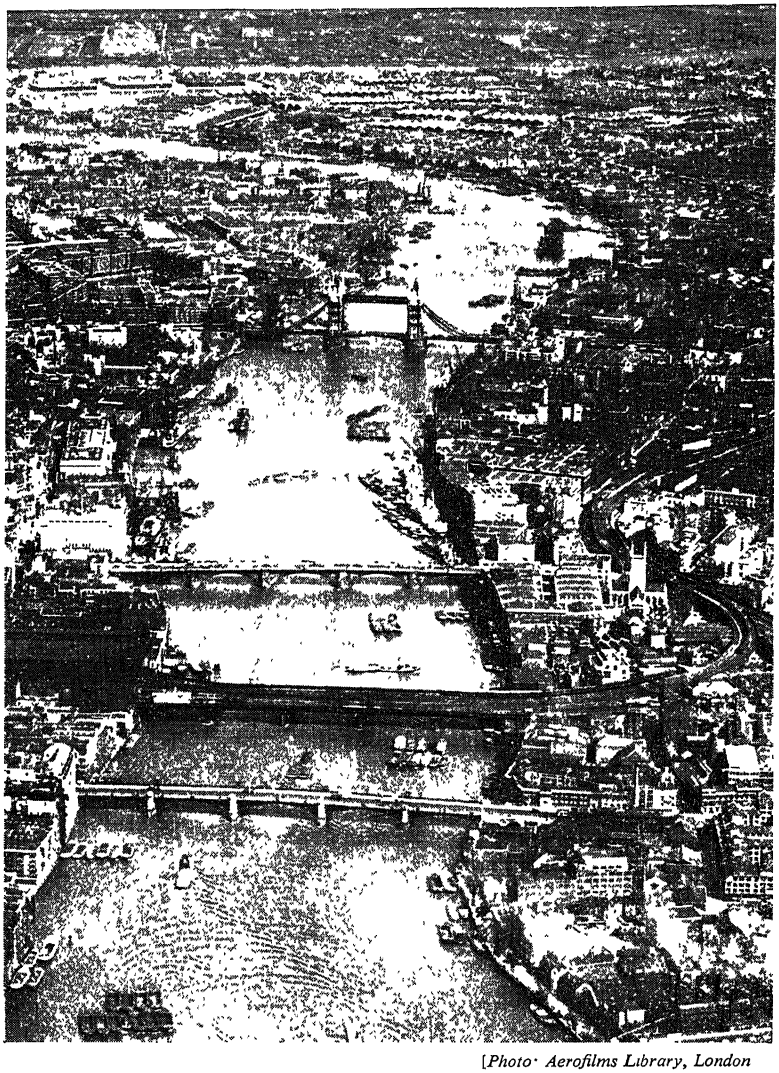


FIG. 260.—Population changes, 1931–1951 in the administrative divisions of Greater London. For comparison with Fig. 259

periphery of the London area have their local functions as market towns serving (with the help of local motor-bus services) the immediate countryside, as well as their functions as dormitory towns for Londoners. One solution to part of the London problem is to



[*Photo: Aerofilms Library, London*

FIG. 261.—"London River"

This view is taken looking eastwards In the foreground are Southwark Bridge, Cannon Street Station and Railway Bridge, and London Bridge The Pool of London is between London Bridge and Tower Bridge, and the steamers of considerable size being offloaded (as at Hay's Wharf on the right) *below* London Bridge but not above show that this is the real head of ocean navigation. Beyond Tower Bridge on the left are St Katharine Docks (surrounded by storage warehouses) and London Docks. On the right are the Surrey Commercial Docks with numerous storage sheds for timber In the far distance is the Isle of Dogs with the West India Docks.

Notice in the bottom right-hand corner a riverside power station (cf. Fig. 262). This view shows also the Tower and Southwark Cathedral.

Although this photograph was taken before the advent of the Second World War, no conspicuous landmarks have disappeared

develop them as self-contained units, rather than as dependents upon London itself.

The influence of the metropolis extends, of course, much farther. A very large part, if not the whole, of the five Home Counties (Middlesex, Hertfordshire, Essex, Kent, and Surrey) as well as Sussex, southern Buckinghamshire, etc., is engaged in supplying dairy produce and vegetables to the London markets. The "economic tentacles" of the metropolis thus extend out in all these directions. The motor car has brought the whole of the south-east coast from Bournemouth to Yarmouth within the normal limits of the car-owning Londoner's Saturday or Sunday trip—with a corresponding congestion on most of the direct roads.

Physical factors influencing the growth of London

The site of early London was determined in the main by the presence, near the navigable channel, of the hills, safe above flood

FIG. 262.—London in 1820

The solid black shows the built-up area at that date
(from Mayne's *The Growth of London*, by permission of Messrs. George Harrap & Co. Ltd.)

level, now crowned by St. Paul's Cathedral and the Royal Exchange or Cornhill. From the early days the physical features of the whole

of the London Basin have not failed to exert their influence on the growing city. Residences spread outwards along the gravel terraces and ridges where a water supply was available, but where drainage prevented a water-logging of the soil. The lower valleys of some of the streams draining to the Thames and many tracts of clay remain to us to this day as the open spaces of Hyde Park, St. James's Park, and others; the Lea Marshes still remain open land. For long the flood plain of the Thames itself must have presented a picture of

FIG. 263.—London in 1945

The solid black shows the built-up area at that date. Figs 262 and 263 are on the same scale (from Mayne's *The Growth of London*, by permission of Messrs. George Harrap & Co. Ltd.)

a waste of marshland, flooded at high tide, but gradually embankment along the southern shore (opposite the City) permitted the formation of "polders" occupied by cattle pastures. Below London, the great areas of marshland, such as the Isle of Dogs, remained until the great dock building companies began to utilise them in the nineteenth century. With the embanking of the river on both sides the water channel was restricted within narrow limits and little now remains to remind us of the extent of the old flood plain. But as London grew, the better residences sought the well-drained heights capped by gravel and the low-lying London

Clay tracts remained undeveloped—occupied by pastureland. The gravel terraces west of London furnished arable land, and Middlesex still sends much market-garden produce to London, though London's great airport at Heathrow has taken up much of the open land which remained. The roads out of London of necessity made for the gaps through the chalk ring; settlement followed along these roads and give an early example of what has later been called "ribbon development." At a much later stage the railways had to seek the chalk gaps and triangular tracts of farmland were left between them. A few tracts still remain: others were built over in the inter-war years. It is found that most which remain are low-lying London Clay tracts. Modern drainage, water supply and improved foundations have played their part in making these clay lands useable, but the better residences sought the chalk slopes or the gravel-capped heights of the Surrey Hills or the Northern Heights. If the London Clay has had some part in preventing a London of skyscrapers and led to a spider's web development, it has assisted in another way the growth of London. Holes can be bored through it with relative ease: hence the network of "tube" railways under London itself, and stretching out northwards and westwards. Where they come upon the harder chalk the "tube railways" emerge at the surface. (For details, see Figs. 42 and 43 in Chapter III).

The Population of London

The following table serves to illustrate the changing nature of population distribution in London:

	City	Remainder of county	Outer ring	Total Greater London
1801	128,129	831,181	155,334	1,114,644
1841	123,563	1,825,714	286,067	2,235,344
1881	50,569	3,779,728	936,364	4,766,661
1921	13,709	4,484,523	2,995,678	7,480,201
1931	10,996	4,385,825	3,805,997	8,202,818
1951	5,268	3,343,068	4,997,801	8,346,137

Note.—All figures before 1951 are adjusted to the modern administrative areas.

These figures are sufficient to indicate the general trend: the decreasing population of the City and adjoining "business" divisions of London. Indeed, the county as a whole has shown a declining population since 1901. The enormous increase is in the outer ring, whilst if one takes the area *outside* the "Greater London" of official reports (*i.e.* the Metropolitan Police area) the percentage increase in the new outermost ring is even greater. This is likely

to become even more marked when the ring of new towns (see p. 630) is complete. In the area outside the county considered in the Abercrombie plan the population rose from 4,084,900 in 1919 to 6,117,300 in 1939. Greater London of the Plan had thus over 10,000,000 people or a quarter of the total for Britain.

There is thus an ever-increasing outward movement of the population, but it must not be forgotten that this is accompanied by an ever-increasing *daily* movement of the people from their homes in the suburbs to their offices, shops, and factories in central London. Thus the resident population of the City of London was, according to the Census of 1921, 13,709, whilst the day population was 416,150—a net influx of 402,441 per day. In most London boroughs there is a daily movement outwards of workers going to their occupations elsewhere, and also a daily movement inwards of workers resident elsewhere. For the County of London alone the number of persons so moving daily was over 2,500,000, a stupendous figure representing 11 per cent. of the total occupied population of the whole of England and Wales at the time.

Even as long ago as 1921, the resident population of the City, Westminster, Finsbury, and Holborn was far smaller in each case than the transient population of workers who moved in and out daily. As the resident population of the central boroughs has decreased, so the daily movement has increased. Broadly speaking, it is the shop and office workers who come in from the suburbs to the City and the central boroughs: the industrial workers live near or at least nearer their work though they often move outwards from the very areas which receive a daily influx of black-coated workers.

The Occupations of the People of London

According to the Census returns for the County of London the principal occupations in 1921, 1931, and 1948 (L.C.C. statistics) were as given in the table on p. 620 (to nearest thousand over 12 years of age in 1921, over 14 years in 1931 and 1948).

If we glance over this list we notice that the transport services—the railways, road, and water services—occupy an important proportion of London's workers, and the number so employed is only exceeded by those in domestic service, in hotels, and cafés rather than private homes. Commerce and the shops, and the clerical staffs of offices each account for large numbers.

But looking upon London as an *industrial* or *manufacturing* centre, the table shows the outstanding importance of the clothing, boot and shoe, metal, furniture, and paper trades. The above table and figures are for the County of London and do not truly reflect the position in London as a whole.

One of the striking things about industrial London is the immense

Occupation	Number engaged 1921			Number engaged 1931			Number engaged 1948		
	Men	Women	Total	Men	Women	Total	Men	Women	Total
All occupations	1,386	781	2,166	1,290	794	2,084			
Agriculture (gardeners, etc)	8	0	8	7	0	7			
Makers of bricks, glass, and pottery	6	2	7	5	1	6			
Chemical workers (including paints)	8	3	11	5	1	6			
General metal workers	116	9	124[1]	103	8	111[1]	89	44	133
Electrical apparatus	24	5	29	26	6	32	275[2]	111[2]	386[2]
Precious metals	5	1	6	4	0	4			
Watch and clock makers	5	0	6	2	0	3			
Leather workers	13	8	21	12	9	21			
Textile workers	3	4	7	2	3	5			
Clothing, boots, and shoes	53	113	166[1]	50	122	172[1]	54	114	168
Food, drink, and tobacco workers	27	19	46	21	11	32	83	59	142
Workers in wood and furniture	70	7	77	63	5	68	66	—	66
Paper makers, printers, etc.	43	31	74	39	24	63	103	59	162
Building trades	46	0	46	63	0	63	766	—	766
Painters	37	1	37	45	3	48			
Transport workers	253	13	266[1]	252	13	266[1]	382	63	445
Railway services	*30*	*0*	*30*	*24*	*0*	*24*			
Road services	*105*	*1*	*105*	*112*	*0*	*112*			
Water services and docks	*41*	*0*	*41*	*36*	*0*	*36*			
Commerce (including shop assistants)	163	62	226[1]	196	73	269[1]	285[3]	223[3]	508[3]
Public administration	72	18	90	331	1	34			
Professional (including teachers)	46	51	97	46	52	98[1]			
Entertainments	14	7	21	17	7	23			
Domestic	77	279	356[1]	105	310	414[1]	77[4]	124[4]	201[4]
Clerical	102	98	200[1]	129	124	254[1]			
Warehouses, packing, etc	45	25	70	50	32	82			
Unskilled labourers	86	3	91	120	30	150			

[1] Note these *leading* occupations. Figures include those unemployed.
[2] Engineering, shipbuilding, and electrical.
[3] Distributive trades.
[4] Catering, hotels, etc

number of small undertakings. In 1930 nine-tenths of the employers in London (not counting employers of less than 10 hands) employed less than 100 hands. At that time there were only 34 undertakings in the whole of Greater London employing more than 2,000 men. However, even so, nearly half the workers were employed by one-twentieth of the firms.[1]

To a considerable extent this is still true. The attraction of London to the small manufacturer is the great reservoir of labour and the huge market of 10 million people close at hand. He can start in a small way, if his product is successful he can expand. Over the past half century the mechanisation of London's industries has been proceeding steadily, in later years rapidly. A distinction is sometimes made between a "workshop" using hand power and a "factory" using power-driven machinery. In 1921, out of 57,000 factories and workshops in the whole of greater London 42 per cent. only were factories using power; by 1929, out of 55,500 no less than

[1] Details from *The New Survey of London Life and Labour*, II. "London Industries," London, P. S. King & Sons, Ltd., 1931.

54 per cent. used power; at the present day the workshop operating entirely by hand has become rare. The outstanding fact of the inter-war industrial development in Britain was the move southwards, especially or mainly to London, of numerous workers from the north and midlands. It is definitely wrong to state that the *industries* have moved southwards: those of London are for the most part of a different type, and among them are especially *new* industries (e.g. connected with electricity, wireless, etc.).

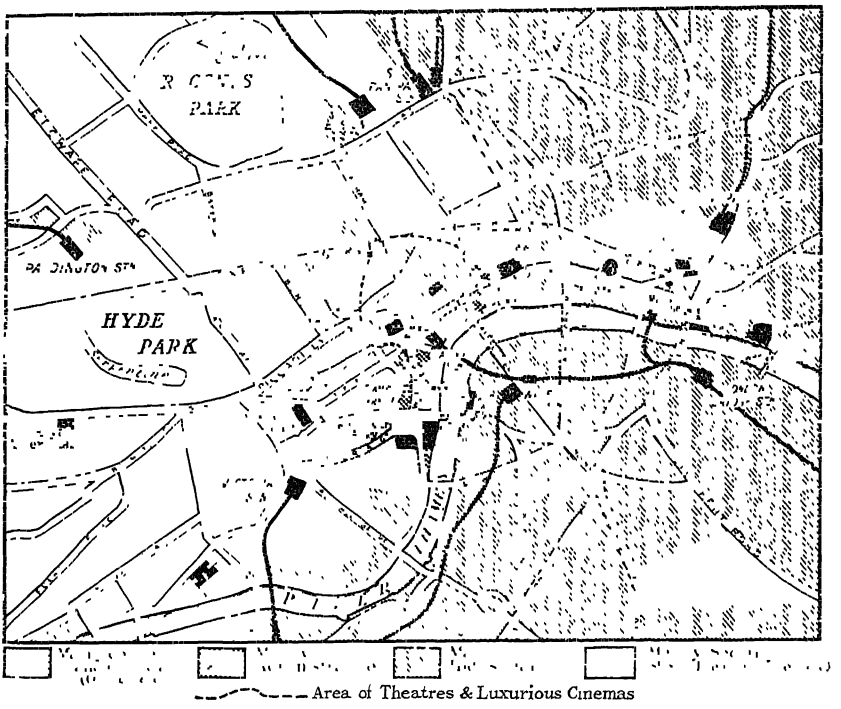


FIG. 264.—The "Functions" of London

London is an excellent example of a large city in which definite areas are devoted to the main functions of the city. The blank areas are mainly residential

The Industrial Districts of London

In the years 1932 to 1938 inclusive out of 3,635 new factories opened in Great Britain no less than 1,573 were opened in Greater London; out of 2,994 closed only 1,055 were in Greater London. Taking the net gain in numbers at 641, no less than 518 were in Greater London, or 80 per cent. of the whole of Britain. The outstanding feature in London itself was the general movement towards decentralisation. It must be admitted that the development

of new factory areas in and near London was, in the main, haphazard. It is obvious that (*a*) labour supply; (*b*) space for expansion; (*c*) transport facilities; (*d*) relation to markets, and (*e*) water, gas, and electricity supplies and costs, and rates were leading factors.

The small factory must needs be erected near an existing labour supply. But labour is mobile and a large unit, complete with housing scheme, can attract labour to itself. So there was the rise of new industrial centres, such as Letchworth (no less than 35 miles from London), Welwyn (21 miles) and, nearer in, Slough. There is a difference of opinion amongst manufacturers as to whether the factory to be erected near an existing residential tract should be on the outskirts so that the workers go *outwards* to their work, but have the amenities of town life at their doors, or whether the factory should be as central as possible and the workers come *inwards* to their work from homes where circumstances permit of small gardens for each. There is no doubt that want of space for expansion is by far the most important reason for moving an established industry. The modern mechanised factory requires a horizontal lay-out rather than a vertical one, hence the great demand for space. In choosing the new site, transport facilities play a large part. For heavy and exporting industries (and for industries dependent upon bulky imported raw material) the importance of the nearness to the river or docks is paramount. This is very clear in the case of such industries as:—

(*a*) Electric power works and gas works—all using water-borne coal and practically all situated near the river or waterways, such as the Regents Canal.

(*b*) Cement works, an example of a heavy and exporting industry, using chalk, mud or clay and water-borne coal, all along the Thames below Dartford, and the Medway.

(*c*) Paper works, petroleum refineries, grain mills, and sugar factories using bulky imported raw materials.

On the other hand, for lighter industries and those supplying primarily or largely the home market, nearness to the main railway lines or arterial roads is more essential. This is clearly exemplified by the almost continuous succession of factories built between the wars along the old Great Western main line from Ealing through Slough with such examples as the gramophone works (H.M.V.) at Hayes, Middlesex, and the gigantic bakeries of J. Lyons & Co., Ltd., or the Park Royal Breweries of Arthur Guinness & Son, Ltd.

This separation of heavy and light industries fortunately operates to a considerable extent in another way. It coincides to some extent with a separation between "dirty" or "noxious" and "clean" industries—to the advantage of residential areas. There is an element of danger associated with explosives and even with oil refining,

with a consequent attempt to isolate them. Shellhaven and the great new refineries on the Isle of Grain afford excellent examples.

There is, of course, another great factor at work where essentially skilled labour is required—the factor which may be called inertia.

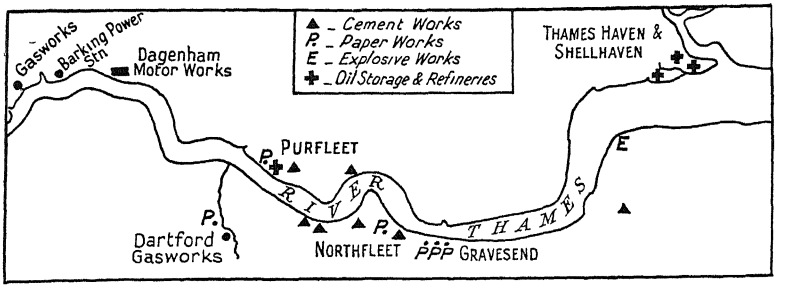


FIG. 265.—Riverside industries of the Thames below London

In particular "heavy" industries and those carried out away from main centres of settlement. (Compare oil refining and manufacture of explosives)

It operates in the clothing industry, which has expanded in the east and north-east of London rather than changed its location.

Mention was made above of the relation to markets. There are several points of view here. Those manufacturers who depend on the London area as their chief market must be near at hand for

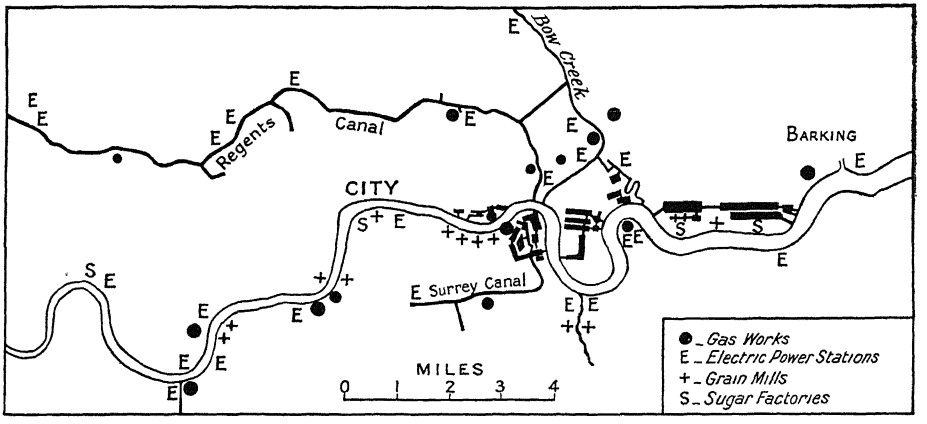


FIG. 266.—Riverside industries of the Thames at London

This map shows that all the major power stations and gas works have water connections (major stations only included)

delivery; those who rely on London as an international mart and are manufacturing for export must be near both for shipment of goods and to permit foreign buyers to inspect their goods. A foreign buyer might well cut off from his list a factory whose warehouse was inconveniently far away for him to visit. The makers of

bulky or standardised articles, of course, get over this by a showroom in London, but even then comes the difficulty that the buyer cannot talk personally with the principals of the business.

The Greater London Plan, 1944, includes a map showing what it calls the "main factory groups" and gives brief descriptions of those outside the bounds of the County of London. We may list the present industrial areas of Greater London:

The East End.—This traditional industrial area of London lies mainly in the Metropolitan Boroughs of Shoreditch, Bethnal Green, Stepney, and Poplar, together with those parts of West Ham comprising Canning Town and Silvertown. South of the river, Bermondsey may be included. Some of the medieval crafts still survive, such as the bell-founders of Stepney, and at least until the last war there were still silk-weavers at Spitalfields using hand looms as old in design as the industry itself. In the 1880's, when transport was entirely horse drawn or the docks reached by the sulphur-laden "underground" of the Metropolitan Railway, shipbuilding was important along the river, ship repairing even more so. Shipbuilding is dead, ship repairing almost so, but to some extent modern engineering industries have grown out of the old shipbuilding, and the close connection with the sea is maintained by very large numbers of dockers and lightermen. Away from the river, furniture making, the clothing industry, printing and cardboard-box-making, tobacco industries, and food processing rank high. By number employed and value of output, London ranks first among the urban centres of Britain in many industries. Before the bombing and destruction of 1940–1945 about a third of a million workers were employed in the East End. Shoreditch and Bethnal Green thus form the "city of the smaller trades and the lesser ingenuities"—the metropolis of the furniture trade. Stepney, on the other hand, takes precedence in the clothing trades. Tobacco is important in both. London does not to any appreciable extent manufacture textiles. The textiles required for the clothing trades are imported. Of recent years there has been a marked increase in the number of factories (i.e. using power) and the numbers employed, but there are still hundreds of small employers with from one to five or more "hands" carrying on their businesses in small workrooms or in a house which is used in part as a residence, in part as a workshop. Homework, or work taken home by these employees, is much less important than formerly.

Similarly with the furniture trades. More than half the output is still from small workshops, but the small man usually specialises, often in one process. The chair-frame maker may do nothing else; a man may do nothing else but turn legs for tables. A common sight in Shoreditch is the man with his barrow-load of partly made furniture en route for the next stage in its manufacture.

Whilst the home of leather tanning and the leather industry is in Bermondsey across the river, the manufacture of leather goods is by no means unimportant in the East End where, however, fur-dressing and furriery is particularly important. But what must again be stressed is the immense variety of miscellaneous industries—old crafts being found side by side with the manufacture of wireless and television parts, or a range of plastic "gadgets" inseparable from modern life.

Soho and the West End.—The back streets of the West End of London still harbour small clothing and other factories conveniently situated to their actual retail outlets.

The Lea Valley.—This is really an offshoot of the congested East End Boroughs, from which population, soon followed by industry, began to move from 1880 onwards and the quiet fertile valley from Waltham Abbey southwards to Enfield, Edmonton, Tottenham, and Walthamstow was changed to a broad ribbon of small homes and factories. Up to 1914 the dominant industries were those of the East End—furniture, clothing, and metal working later followed a great diversification. Well served by waterways and rail, the later development came to rely more and more on road transport. In the Lea Valley the intensive production under glass in heated greenhouses of tomatoes, cucumbers, and flowers is organised as an industry rather than as a branch of farming, but necessitated the conservation of considerable areas of land for its use. Once it was good local soil, abundant water, and good sunshine average which attracted the industry, now proximity of markets and a large local labour supply are more important in retaining the industry.

The Lower Thames-side.—This is London's heavy industrial area: in contrast with the areas just described it is essentially one of large units which have occupied the erstwhile marshlands. Examples are the great Ford works at Dagenham on the north of the river; works at Erith, Dartford, Northfleet to the south with the great oil refineries nearer the mouth of the river.

North-West London.—With the exception of a few big pre-1914 firms at Willesden, this area grew up after the First World War, some parts indeed from munition factories, whilst much of the 1924–1925 Wembley Exhibition grounds were given over to light industry, especially proprietary articles and semi-luxury goods including electrical equipment. It comprises Park Royal, Willesden, Acton, Wembley, Greenford, Perivale, Hendon, and the Edgware Road. From the old focus at Willesden Junction industry spread out along the main railway lines—the former Great Western and L.M.S.—and along the main roads (Western Avenue and North Circular Road).

West London.—Development here dates from 1904, but was especially marked after 1918, and there is an almost continuous line of factories from the built-up area of London at Southall to

beyond Slough, which actually lies in Buckinghamshire. The way in which industrial development has clung to the main Great Western line and to the Great West Road shows the importance of transport.

Kingston By-pass, *Wandle Valley* and *Cray Valley* are three rather small and isolated areas of development south of the River Thames.

London's Wholesale Markets.—The covered retail markets of London, small and few, are insignificant when compared with the great covered markets of such towns as Liverpool and Birmingham.

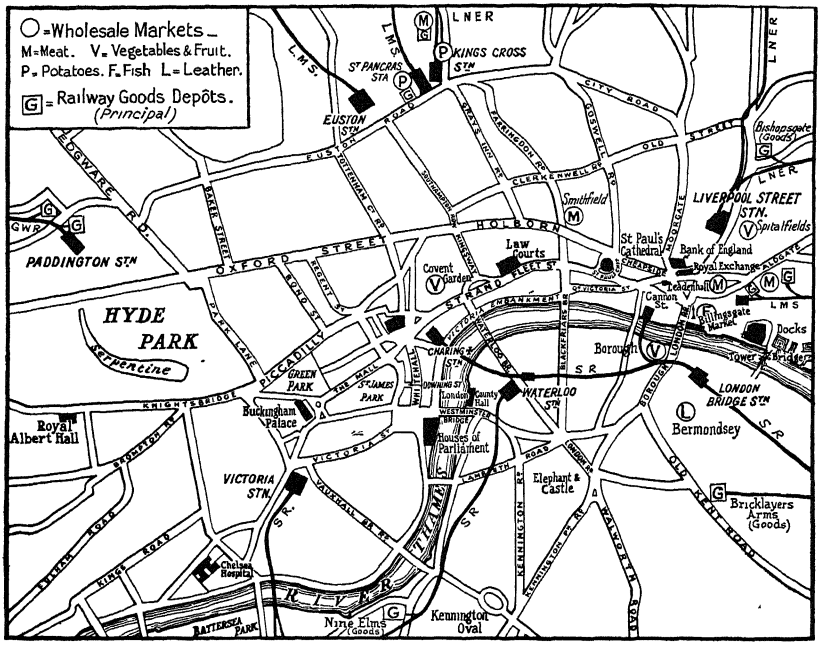


FIG. 267.—London's wholesale markets
Shown in relation to the main railway termini and the docks

London's street markets are more comparable with the covered retail markets of the provinces, and play an important part in London life.[1] But London's wholesale markets occupy (or at least did prior to the outbreak of war in 1939) a unique position in that to a large extent they determine or influence prices throughout the country, and are an outward and visible sign of London's pre-eminence as a commercial centre. With the advent of war, the Ministry of Food took over the bulk purchase of all foodstuffs which it decided to ration—including meat, bacon, butter, cheese,

[1] See *New Survey of London Life and Labour*, III, Chapter XIII, p. 290.

fats, eggs, sugar, tea, and confectionery—and the slow release from rationing after the war makes the future of the old markets somewhat uncertain. Those handling non-rationed foods, notably Covent Garden, continue to function more or less as in the past. In a very large number of commodities transactions are carried out by sample so that the "markets" are or were merely certain streets in the City where firms specialising in certain commodities have their offices located. The tea "market" is or was in Mincing Lane, the jute "market," sugar "market," etc., near at hand. But in the case of foodstuffs where freshness is essential (meat, fish, and vegetables) the commodities are actually brought to the markets of the metropolis for sale.

The City Corporation of London owns five markets, viz. the London Central Meat Market at Smithfield, the Metropolitan Cattle Market and Abattoir at Islington, and the markets at Spitalfields, Billingsgate, and Leadenhall. Covent Garden is owned by a public company, two railhead markets have fallen to the control of British Railways. It is interesting that no markets are controlled by the London County Council which came really too late on the scene. Some of the markets, such as the L.C. Meat Market, serve mainly the London area; others, such as Covent Garden, serve practically the whole country, and there has been much discussion as to devising some means to obviate the delay and expense of repeated handlings necessary to bring such commodities as imported fruit to Covent Garden before re-consigning it to distant parts of the country.[1]

Covent Garden.—Covent Garden is still the principal centre of Great Britain dealing in imported fruit and vegetables, and also handles a seasonal surplus of fruit from south-eastern England. The market was founded in 1670 in the reign of Charles II. The market itself covers $5\frac{3}{4}$ acres including open squares, covered market buildings and a Floral Hall where auctions take place. Most of the premises in the neighbouring streets are occupied by firms in the fruit and vegetable trade. The market is chiefly active between 3 a.m. and 6 a.m., when the home-grown supplies reach the market, and over 5,000 vehicles go into the market in one day. It cannot be claimed that the market premises are up to date, and the congestion is notorious.

Spitalfields.—The market founded originally in 1682 was long associated with the old fine silk industry of the area. It is now the market for fruit and vegetables, mainly from Essex and the eastern Home counties supplying the populous east and north-east of London.

Stratford.—This is a fruit and vegetable market adjoining, and constructed in 1878 by, the old Great Eastern Railway. It derives its supplies from the counties on that line. The railhead depots at King's Cross and Somer's Town have a similar function—handling the potatoes and vegetables of the Fenlands in particular; while the Borough Market serves the south of London. Greenwich has also a small wholesale fruit market.

[1] A South African farmer once told the writer that a case of oranges was handled fifteen times before it was opened in a retailer's shop in England. Five of these were necessitated by the existence of the Covent Garden system.

The London Provision Exchange.—Established in 1887, this market normally handles the whole of the bacon and ham imported into London —about half of the total imports of the country. It is concerned also with butter, cheese, lard, and canned goods.

Smithfield.—The London Central Market, owned and operated by the Corporation of the City of London under a charter of Edward III, covers now an area of 10 acres and is the principal meat market, dealing also in eggs, poultry, game, butter, and cheese. From the point of view of ease of approach and facilities for handling the meat, Smithfield is the best of London's markets. 60,000 sides of beef (about 9,000 tons) can be displayed at once: there are external loading points for 350 three-ton lorries at one time and 31 ample gates to the market itself. There are numerous cold stores adjacent to the market. The incoming lorries deliver their loads and are away between 4 a.m. and 6 a.m. The retail butchers do most of their purchasing between 6 a.m. and 8 a.m.

Islington.—Islington Market is especially important as including London's chief slaughter houses. Most of the meat goes to Smithfield.

Leadenhall Market.—Handles mainly poultry and, not being far from Billingsgate, is convenient for retailers who sell both fish and poultry; though more poultry is being handled at Smithfield. There is also an important retail market.

Billingsgate.—Billingsgate fish market more than rivals Covent Garden in historic interest. It is the oldest of the markets controlled by the City Corporation, and its site—by the river-side around a small haven just below London Bridge—was inevitable when most of the supplies were water borne. Actually the proportion of water-borne deliveries has now dropped to a small fraction of the total, and the bulk has therefore to be brought from the great railway termini. Although the market serves primarily London and the south-eastern counties, not a small proportion is conveyed to distant points in the south—possibly not far from where the fish was originally landed. The market itself, with an area of about an acre, is incapable of accommodating the quantity of fish to be sold. Thus much of the selling is by samples, and delivery can be made from the railway companies' vans which line the "Inner Circle" of streets surrounding the market direct to the waiting buyers' vans which line the "Outer Circle" of side streets. The market opens at 5 a.m. when deliveries arrive from the special night fish trains. Retailers arrive at 6 o'clock and most of the business is over by 8 a.m. and the streets clear before the great throng of city workers pours through the neighbouring thoroughfares at 9.0 or 9.30.

The other markets are indicated on Fig. 267. The old Hop Exchange was off the Borough.

London during the Second World War.—London was so obviously the nerve-centre of Britain and the Commonwealth that it was reasonable to presume an immediate massed air attack in the event of war. Consequently, when war broke out in September, 1939, pre-arranged plans for the evacuation of mothers and children, for the decentralisation of government and the setting up of autonomous Civil Defence Regions covering the whole country, as well as the dispersal of commerce and industry, were immediately put into effect. The serious attack did not in fact come for nearly a year, but in the winter of 1940–1941 nightly raiders caused much damage, especially by incendiary bombs. Dockland, the East

End and parts of the City suffered severely. After April and May there was something of a respite until the advent in the later stages of the war of the guided missiles (flying bombs, or V1's), and then the giant projectiles, or V.2's, with great destructive power. Although large numbers of evacuees, including children, had drifted back to London, London's normal activities remained greatly reduced. The Port handled but a fraction of its pre-war volume of trade, many of the City's commercial and business firms carried on from addresses scattered widely through the country, few industries of national importance continued to function in London. Even so, shops, restaurants, hotels, cinemas, and theatres carried on and because many businesses did not do more than move from the centre to the suburbs the population of Greater London probably never dropped below two-thirds of its 1939 total. That of the County of London reached a low of 2,314,700 in December, 1941, compared with 4,062,800 in mid-1938.

London after the Second World War.—The end of the war was marked by an immediate rush to return to London—of individuals, of business and commercial houses, of industry and even of Government departments. Decentralisation, previously advocated as desirable, necessitated by the war, had proved to have many disadvantages. Although careful and imaginative plans had been prepared for the rebuilding of city, county, and suburbs, it was difficult for several reasons to put these into effect. Bombing had resulted in spasmodic rather than systematic clearing of large sites, and the shortage of houses was so acute that any dwelling which could be repaired and made habitable had to be so used, thus postponing demolition of obsolescent buildings indefinitely. Priority of labour and materials had to be given to housing, and work on large office blocks, as well as hotels, cinemas, department stores, and other "luxury" work, even including factories and warehouses, had to take second place. By 1952 scarcely a start had been made on rebuilding the City. On the other hand, the expansion of the civil service to staff such new ministries as Food and Defence, Housing and Local Government and to take care of nationalised industries—such as coal and transport—involved the spread of Government offices to many parts of London. In some cases, as in the east side of Regent's Park, their use as Government offices saved much of Regency London—houses which private occupiers could no longer afford to maintain. With the destruction of some large shopping areas, the remaining areas had become much congested, and shops and offices have still further invaded the formerly residential areas, notably of Mayfair. The westward migration of varied light industries became more marked, partly because of the relatively slight war damage when compared with the East End. Shipping and trade returned to the London docks and the influence of water

transport is still strong enough to concentrate recent development of power stations on Thames-side and an expansion of the great self-contained iron–machinery works of Ford at Dagenham.

The Future Development of London

Modern London illustrates in a remarkable way the separation, which is characteristic of most of the very large modern centres,

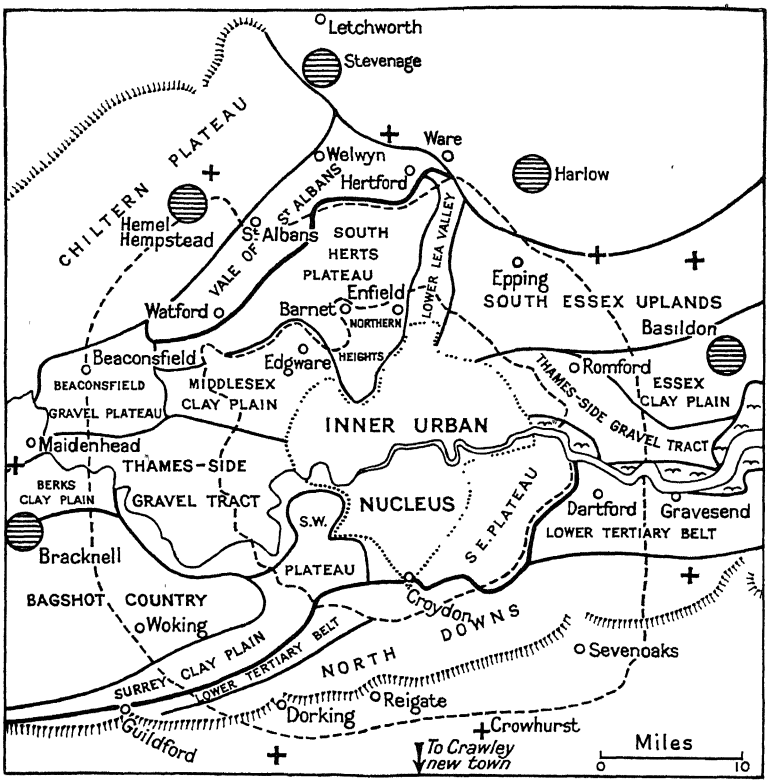


FIG. 268.—Greater London in relation to the surrounding physical regions (after S. W. Wooldridge, *Trans. Inst. Brit. Geog.* 1946)

Crosses: sites proposed for new or satellite towns in the Great London Plan of 1944. Circles: new towns actually constructed

of areas serving each of the five great functions of a city: the commercial, the administrative, the industrial, the social, and the residential. As a result of the destruction wrought by bombing in 1940–1945, the areas have become less clearly defined and the expansion of central administration in particular has caused Government offices to appear in most unexpected places. Normally the heart of commercial London is the City with its banks, its in-

surance houses, its business premises, its warehouses, and its markets. On the one side to the east it is very closely linked with the Port of London. Much of the buying and selling is actually done by samples in the City whilst the goods themselves remain in the Port. The growth of commercial London was driving out the resident population in many western areas long before the outbreak of war in 1939. Bush House is outside the city limits. The replacement of the old Cecil Hotel by the giant Shell Mex building was another indication of the spread of commercial London. Social London remains with some difficulty in the West End. Here in juxtaposition are the theatres, the cinemas, the large stores, and attractive shops, the clubs, restaurants, and hotels within reasonable access to the principal railway termini.

A question brought very much to the fore is the question, Should London be *allowed* to grow? Between the wars more than 10,000 new factories were built. The transport of London's workers from their homes to their work threatens to become an insoluble problem despite the coordination of the transport services under unified control and new schemes for further railway electrification.

Consequently the London Plans emphasise physical limitation by a green belt and accommodation of "overspill" population in self-contained new towns 20 to 50 miles from the centre. In the meantime the concept of the "neighbourhood unit"—a town within a town—has grown, though it merely crystallises the old local allegiance denoted by such neighbourhood names (they are not administrative units) as Bloomsbury, Mayfair, Belgravia, and Chelsea. If people *want* to live in London should they, in a free society, be prevented?

In accordance with this policy the building of a ring of new towns was undertaken. They are shown in Fig. 268—Crawley in the south, Bracknell in the west, Hemel Hempstead, Stevenage, and Harlow to the north, Basildon to the east in Essex.

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CHAPTER XXVII

THE GROWTH OF COMMUNICATIONS[1]

THE history of the development of facilities for communication in the old-established and highly industrialised country of Britain is a subject so vast, and withal so well supplied with literature,[2] that in this chapter, fascinating though excursions into economic history might prove to be, we can scarcely hope to present more than a brief essay in the geography of transport and an analysis of the relative importance of geographical and other factors in influencing the growth of roads, canals, and railways.

Two features of fundamental importance have played a part in modelling our present transport system. In the first place, one may say that Britain is, on the whole, by its physical nature, well favoured for the development of two out of the three major modes of communication—road and rail. There exist very few real barriers to road construction in the shape of high mountain ranges or wide marshes, and the "negative" areas are of such small extent that both roads and railways can round the obstacles without long detours. The all-important raw materials, both for road making and for the road beds of railways are widely distributed (cf. p. 337), and railways are, in addition, favoured by the existence of fuel supplies of excellent quality—a fact which has had no little influence on British locomotive design and practice. For canals, however, the undulating surface of Britain, with its industrial regions separated for the most part by upstanding areas of harder rock or by alternating scarps and dip-slopes, is not nearly so well adapted as, for example, the flat plains of the Netherlands and North Germany; whilst long navigable rivers free from vexatious sinuosities are non-existent. Although Britain passed through a canal era of great importance in its industrial development, it is not suprising that this form of transport should have seriously declined with the rapid expansion of railways.

Secondly, a characteristic feature of the development in Britain of railways, canals, and the "turnpike" roads has been the dominance of private enterprise and the virtual absence, from the Roman

[1] By S. H. Beaver.

[2] Standard works are Jackman, *Development of Transportation in Modern England*, 2 vols., 1916 (a solid and well-documented piece of research); and Pratt: *History of Inland Transport and Communication in England*, 1912 (a more popular and more readable account).

period until quite recently, of Government assistance.[1] This strict adherence to laissez-faire principles, with its preservation at all costs of open competition, lest a dreaded "monopoly" should come into being, has been responsible for many of the difficulties of the present transport system, and for many of the differences which exist between Britain and Continental countries. There has been no national plan, as in the case of the railways and "routes nationales" of France; instead, the systems grew during periods of boom—the canal "mania" of the 1790's and the railway "mania" of 1845–1847—in haphazard fashion, without much sound geographical basis or real economic need. Turnpike trusts were established in large numbers, in many parts of the country, with little reference to the economic needs of the period; canals—long since derelict—were constructed through areas where neither through nor local traffic could reasonably be expected to yield a profit. Some of the early railway lines were similar; others were constructed merely to act as competitors to already existing lines.

With these preliminary considerations in mind, we may attempt very briefly to trace the history of transportation in this country.

The Roman roads, military in origin and well planned and constructed, were for the most part stone causeways following a straight course from beacon to beacon across the higher and more open ground above the forests and marshes of the lowlands.[2] Even at this early stage the importance of London as a focal point was well marked (cf. Fig. 237). For a long period after the departure of the Romans little attention was paid to communications, and although many improvements were made in the thirteenth and fourteenth centuries conditions of transport subsequently deteriorated considerably. Rivers were undoubtedly more important than roads, and nearly every town of any size was a river port (*e.g.*, York, Lincoln, Gloucester, Chester) (cf. Fig. 248). The accessibility of the university towns of Oxford and Cambridge was certainly improved by the waterways of the Thames and Cam. Towns such as Birmingham and Bradford, not on navigable streams, were non-existent or of no consequence.[3] The medieval roads were mere trackways, the actual route of which was constantly shifting to avoid the more dilapidated patches.[4] There was but a meagre demand for intercommunication between towns and villages when subsistence agriculture and domestic industry were the rule, and the upkeep of the roads was regarded as a charitable occupation and

[1] Note, however, the military roads of the Scottish Highlands, constructed in the eighteenth century by General Wade and his successors, and the costly but rather useless Caledonian and Crinan Canals built with Government money.

[2] See Ordnance Survey Map of Roman Britain.

[3] Birmingham remains an example of one of the very few large towns in the world actually on or near a water-parting.

[4] This continual departure from a direct course may possibly explain some of the curious sinuosities in the present-day roads.

so left mainly to the monks. With the breakdown of the manorial system, the decline of the fairs and the cessation of pilgrimages, and, finally, the dissolution of the monasteries, the roads grew worse and worse. An act passed in 1555 delegated the labour of road mending to the parishes. This measure actually remained in force until 1835, but it really cannot be said to have succeeded in greatly improving the road system, for the statutory parish labour was easily evaded and the methods employed were of the most primitive order. There was still no pressing need for efficient roads until the trade of the country, both internal and external, began to expand in Elizabethan times. The fairly late introduction of industry into Britain, when compared with certain parts of the Continent, is largely due, in fact, to the difficulties of internal transport.

The increase of wheeled traffic played havoc with the layers of mud and stones which passed as roads in the seventeenth century. Long covered wagons had begun to be used in the sixteenth century, and stage coaches made their appearance fairly early in the seventeenth century, and the result was a series of regulations concerning weights to be carried and width of wheels, it being thought that wide rims would cut up the roads less than narrow ones. The legislation, it should be noted, was concerned with adapting the vehicles to the roads, not with improving the roads to accommodate the vehicles. Descriptions of roads and journeys during this century and a half (1600–1760) are numerous and entertaining. The "Tours" of Defoe[1] and Young have been previously referred to in this book. It was indeed an adventure almost equivalent to a modern crossing of Central Africa to undertake a long journey through Britain, and it is little wonder that those who performed such travels wrote at great length of their experiences. The many clay belts of England were areas of especial difficulty. In the winter the roads across these regions were almost impassable, and the sparse settlements were isolated for months on end. Of particular ill-fame were the roads across the Weald Clays of Sussex, across the London Clay, Gault, and Oxford Clay belts which intervene between London and the Midlands, and across the bogs of South Lancashire. Heavy lumbering carts with their numerous horses cut the roads into deep ruts, and the laying of stones only served to make progress more dangerous and uncomfortable for travellers on horseback or in wheeled vehicles. Of the road to Wigan, Arthur Young says: "I know not in the whole range of language terms sufficiently expressive to describe this infernal road . . . eighteen miles of execrable memory." Obviously industrial development was not aided by such conditions, and South Lancashire and the Birmingham

[1] See especially Appendix to Vol. II of Defoe's *Tour thro' the island of Great Britain* (original edition, 1724–1726).

region, especially, found themselves hampered by the difficulty of disposing of their goods. Road speeds, too, were extremely slow. In the middle of the eighteenth century, Edinburgh was 10 to 12 days' coach journey from London, Exeter 4 days, Birmingham and Dover 2 days, and so on. It was with the object of improving road conditions that the Turnpike Trusts were set up. The first of these was instituted in 1663 on a section of the Great North Road in the clay belt between Hertfordshire and Huntingdon; their object was to obtain money for maintaining the roads in good condition by charging tolls. About 1,100 separate trusts were formed, the greatest period being 1760–1775; but many of them controlled only a few miles of road, and large numbers were thoroughly inefficient, most of the tolls going towards the payment of trustees' salaries. There is no doubt, however, that the turnpike movement did an enormous amount of good for road transport, especially after the advent of new methods of road making. Until the beginning of the nineteenth century the construction of roads was not regarded as an occupation worthy of the skill of engineers, and, as we have seen, the authorities tried in vain to adapt the traffic to their poor surfaces. Between 1810 and 1820, however, two men, Telford and McAdam, began to apply scientific principles to road building; Telford, who commenced reconstructing the Holyhead road in 1815, concentrating upon the creation of a solid foundation and adequate draining; McAdam, who attained the position of "Surveyor-General of Roads" in 1827, devoting his attention to the production of the durable, impermeable surface which still bears his name.[1] A great impetus was thus given in the 'twenties and 'thirties to the development of coaching traffic. Just when the Turnpike Trusts were beginning to set the roads of Britain in good order a new form of transport, the railway, entered the field and deprived them of much of their revenue. During the second half of the century they were all wound up, the control of the roads passing into the hands of Parish Councils and Highway Boards, and later into those of the reconstituted Local Government bodies, County, Borough, Urban, and Rural District Councils. Thus road transport for several decades became a matter of local importance, until the evolution of the petrol motor rendered the construction and maintenance of roads of first-class national significance.

The age of bad roads, in the seventeenth and eighteenth centuries, is marked by an increased attention to river navigation. The natural waterways had been for so long neglected that their beds

[1] The essential point of his work was the discovery that stone broken to a uniform size and of angular shape could be made to bind together. The tarring of the pieces (and the making of tar-macadam) with the consequent elimination of dust, is a twentieth-century development. The reinforced concrete road has gone still further to solve the problems of roadmaking in country with a soft subsoil.

had become silted up, and disastrous floods occurred after periods of heavy rainfall. Thus, many medieval ports, such as Lewes, Ely, Bawtry, York, and Doncaster, had been deprived of their position and had lost in trade and importance thereby. The first Act for improving a river was actually passed in 1424 concerning the River Lea (an important highway for London's wheat supply), but the great age of dredging and artificial cutting (to avoid the frequent meanders) was between 1660 and the beginning of the canal era. Although rivers all over the country were subjected to much improvement, the greatest incentive came from the north of England, where industries were beginning to develop rapidly. Thus the Mersey was improved as far as Warrington in the 1690's, and in 1720 three new projects were sanctioned—the Mersey and Irwell navigation, giving navigable water as far as the growing town of Manchester; the Weaver navigation, opening up the Cheshire salt-field; and the Douglas navigation, providing an outlet for the Wigan coalfield to Preston. The Aire and Calder navigation, commenced in 1699, stimulated the growth of Leeds and Hull, and the improvement of the Don enabled the manufacturers of Sheffield to obtain an easier outlet for their valuable produce.

The various disabilities attaching to river navigation, however, such as time wasted in following the innumerable windings, the difficulty of towing upstream, and the fluctuation in depth of water according to season, together with the fact that several growing industrial areas, such as Birmingham and the Potteries, were not served by navigable rivers, led to the development of artificial waterways or canals. The link between the two is the Sankey Canal, sanctioned in 1755 as a river improvement scheme to provide an outlet for the Wigan coalfield. The improvement of the Sankey Brook being found impracticable, an entirely artificial cut was made. From this small beginning an extensive canal system came into being within the next 60 years. The canals were built by private enterprise, competing with the Turnpikes, and the companies were modelled on the lines of the Trusts, that is, they were toll-takers, and not carriers. As a result, there was great variation in depth and width, size of locks, and gauge of tunnels, etc., and through long-distance traffic was compelled to pass over the property of several different companies.[1] At first, however, the improvement in speed upon road transport, the reduction of freight rates to about a third or a quarter of the amounts charged on the roads, and the ability of the canals to carry bulky raw materials and finished goods in hitherto inconceivable quantities sufficed to enable many of the canals to pay enormous dividends.

Geographical influences in the growth of the principal elements

[1] *E.g.*, Birmingham to Liverpool, six canal companies, each canal of different dimensions; Liverpool to Hull, ten companies.

in the canal system—if it can be called a system—are very evident. The increasing use of coal in industry and as a household fuel, together with the industrial development of the Midlands and North, where the roads were particularly bad, were responsible for the greater part of the canal cutting taking place in those areas, whilst the South was left—with one or two exceptions—comparatively untouched. The Black Country, South Lancashire, and the West Riding became the principal foci, London, with its river navigation and coasting trade, being distinctly ex-centric in marked contrast to its position as regards the roads and later railway nets. In Lancashire and Yorkshire three needs were being catered for: (*a*) more adequate disposal of coal; (*b*) easier transport between the cotton and woollen centres and the coast; (*c*) coast to coast communication, in order to avoid long coastal voyages. Thus, the Worsley Canal linked the Duke of Bridgewater's collieries with Manchester, the Bridgewater Canal gave the cotton capital a new and better outlet to the Mersey estuary, and the Leeds and Liverpool Canal, and also the Rochdale and the Huddersfield canals, linked the navigable waters on either side of the Pennines. The Leeds and Liverpool Canal, especially, was responsible for much new industrial development in the Aire valley and in the valleys north of Rossendale Forest. The great canals of the Midlands fall into two groups. In the first place there is the complicated system in the Birmingham–Black Country region, which afforded much-needed outlets for coal and the bulky produce of the iron and other metal industries; secondly, there are the canals designed to link up the major navigable rivers. Of these the most important were the Grand Trunk from Trent to Mersey, which had a truly remarkable effect upon the development of the Potteries, where Wedgwood had just recently (1763) begun his improvement of the staple industry (cf. p. 554); the Shropshire Union, linking the Birmingham system with the Mersey; the Staffordshire and Worcestershire, linking the Birmingham system with the Severn; the Grand Junction, giving navigable water from London to Birmingham and the Trent; the Thames–Severn (across the Cotswolds to Stroud) and the Kennet–Avon. These inter-riverine canals were instrumental in displacing a great amount of coastal sailing; when coasting steamers developed they lost most of their traffic, and the last two, for example, are now disused. South Wales also developed canals as an aid to its coal export trade—the Monmouthshire and Glamorganshire valleys providing obvious lines of movement to the ports of Newport and Cardiff. It is noteworthy, however, that Northumberland and Durham—the home of wooden and iron tramways (*vide* Chapter XIV and *infra*)—never adopted a canal system. In Scotland the Forth and Clyde Canal from Bowling to Grangemouth had as its primary object the connection of the coasting trades of east and west

Scotland[1]; but the Monkland Canal (from Coatbridge to the Forth and Clyde Canal at Glasgow) and the Union Canal (from the same canal at Falkirk to Edinburgh) were both constructed to give outlets for the Lanarkshire coalfield. The state-aided Caledonian and Crinan Canals (the former from Fort William to Inverness and the latter across the head of Kintyre) have never been of any real economic importance.[2]

The great boom in canal construction came between 1791 and 1794, during which period 81 new canal and navigation Acts were passed. Many of these were for quite useless canals which either soon went out of business or became absorbed in the larger concerns. The coming of the railway after 1830 was the beginning of the end for a large part of the canal system. In that year the British Isles possessed 4,270 miles of canals and inland navigations (*i.e.* improved rivers), over 3,200 in England and Wales, nearly 200 in Scotland, and nearly 850 in Ireland. By reason of the great industrial expansion of Britain, traffic on many of the canals actually increased until the end of the century, but the total canal traffic was very small beside that carried by the railways.[3] We may profitably summarise the principal reasons why the decline of the canals has taken place and why their resuscitation is impossible.[4]

(1) The narrow canals and rivers of Britain are ill adapted for speedy carriage, for fast-moving vessels create a wash which would quickly undermine the banks. On a number of canals mechanical propulsion is actually prohibited, only horse towage being allowed. On the other hand, on the Grand Union system concrete banks are being provided to enable faster motor boats to operate.

(2) Britain, we have said, is not physically suited to canals. Locks are required in great number and tunnels (many of them without towing paths) are not infrequent, and the resultant delays add considerably to all journey times. Between London and Avonmouth, for example, in 178 miles, there are 125 locks (including a remarkable "staircase" of 29 at Devizes); between Liverpool and Hull, 159 miles, there are 147 (92 in 32 miles over the summit of the Rochdale Canal); between London and Birmingham *via* Blisworth, 159 locks in 135 miles; and between Birmingham and Sharpness 62 locks in 75 miles. At Anderton

[1] Its western terminus was ten miles below Glasgow, owing to the shallowness of the Clyde.

[2] Even modern pleasure steamers start from above the famous "Neptune's staircase" of locks at the southern end of the Caledonian Canal.

[3] 1898: Canal traffic 39 million tons; railway traffic 379 million tons. These are "unreal" figures, since traffic passing from one company to another was recorded by each company and so may figure several times in the total. However, the truth of the generalisation made above is apparent.

[4] See Royal Commission on Canals and Inland Navigation, Cd. 4979, 1909, also E. A. Pratt, *Canals and Traders*, which sets out clearly the arguments against the revival scheme proposed by the Commission.

(near Northwich) a hydraulic lift raises barges 50 feet from the River Weaver navigation to the Trent and Mersey Canal.

(3) A large part of the canal system is of small dimensions, incapable of taking boats drawing more than 4 feet of water, or more than 7 feet in width. Narrow canals are especially characteristic of the Birmingham system, on which special narrow boats must be employed.[1] The impossibility of widening these canals is evident when it is realised that over much of their extent in the Black Country the banks of the waterways are completely built over with factories, works, and even dwellings, many of which, though possibly owing their site to the facilities for water transport, now make little use of them.

(4) Many canals, designed to facilitate coal transport, pass through coal-mining areas in which ground subsidence is of frequent occurrence, and the maintenance of the waterway consequently difficult. Thus, in the Black Country, in Lancashire, and in the Potteries, subsidence has occurred to such an extent that the canals now run in places above the general level of the land, like an embanked river over its flood-plain.

(5) Canals which cross watersheds are likely to experience difficulty in obtaining adequate water supply. Were such canals to be enlarged, great reservoirs would need to be constructed in order to render navigable the deeper and wider channels.

(6) Turning from the physical to the economic side, we find that the great disadvantage of the canal is its lack of flexibility and its capacity for serving adequately only those factories, mines, and farms which lie along its banks. Owing to the initial cost and difficulty of construction, a canal is very much less flexible than a railway. Canals, moreover, are not well adapted for carrying small loads to a number of different points. The railway, with its 12-ton wagons, possesses here a distinct advantage over the 50-ton boats of the waterway. A characteristic feature of modern commerce is the forwarding of small parcels at frequent intervals; for such traffic the canal cannot compete with rail and road.

(7) A certain part of the canal system began to decline during the second half of the last century through falling into the hands of the railways. The railways, for the most part, were not anxious to purchase the canals; they were almost forced to do so, since the canal companies, seeing their traffic dwindling, threatened to set up competitive rail lines, and the railway companies in self-defence bought them out. Thus, in 1845 the Birmingham Canal Company threatened to build a new railway parallel to the London and North Western line, and so the railway company took over the management and guaranteed

[1] It is not the open channels of the canals which are narrow, but the locks and bridges which it would be very difficult and costly to widen.

the shareholders an annual dividend of 4 per cent. Some of the railway-owned canals still carry a fair amount of traffic—for, until nationalisation brought them all under the control of the Inland Waterways Executive, the railways were under obligation

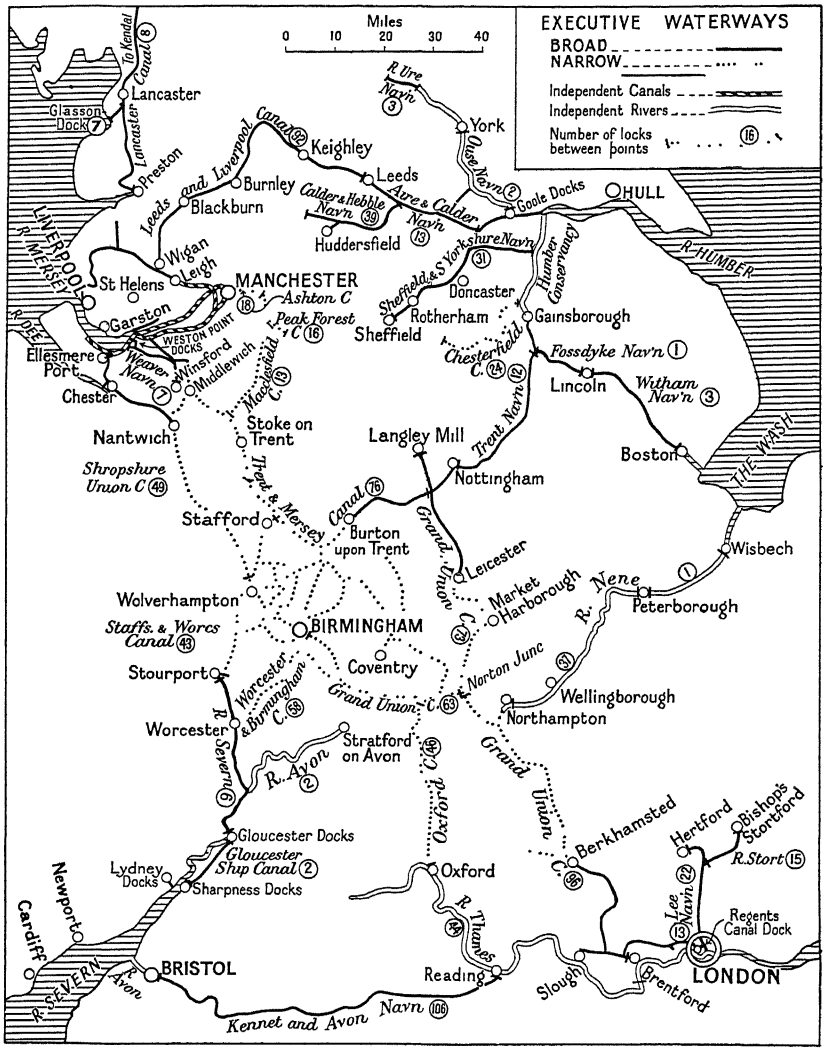


FIG. 269.—Navigable waterways of England and Wales, 1951

to maintain their waterways in navigable condition—but others are slowly dropping out of use.

(8) A last disadvantage of canals in Britain is the comparatively short haulages which can be performed. No industrial town of

moment is more than 80 miles from a seaport, and so much of the traffic which is suitable for water-carriage is taken by coasting steamers.

In spite of all these disabilities, however, and in spite of the indispensable service which the railways and roads are able to offer, waterways have still an important contribution to make to industrial development, and when their facilities are available alongside other means of transport and in a district convenient for distribution there are positive advantages offered to certain traffics, as, for example coal and china-clay. Fig. 269 shows the navigable waterways existing in 1951—with an indication of the numbers of locks. Apart from the lower reaches of the Thames, Severn, Humber, Mersey, Tees, and Tyne, the principal canals and navigations are the following: Grand Union (for local London traffic and through traffic, London to Birmingham, Leicester, and Nottingham), Shropshire Union (carrying much traffic between the Black Country and the Mersey), Trent and Mersey (Potteries to Mersey section only), Leeds and Liverpool (chiefly on the Lancashire side), the Birmingham system (mainly local traffic, especially coal from Cannock Chase pits to Black Country factories), the Aire and Calder Navigation (giving long haulages, comparatively free from locks, between the West Riding and Goole), the river Trent below Nottingham, the Birmingham and Wolverhampton–Bristol Channel connections, and, of course, the Manchester Ship Canal. Many formerly important rivers now carry little or no traffic (*e.g.* the Dee, Idle, Nene, Welland, Bedford Ouse, Yorkshire Ouse above York, Witham, Wharfe, and Wye), and the "navigations" of the Fen country (the main object of which is drainage) are almost disused. The only important navigable waterway in East Anglia is the river Yare from Norwich to Yarmouth.

Just as the canal system owed its origin to the growing dissatisfaction with the bad roads of the eighteenth century, so a large part of the railway system grew up in the first place to supplement the inadequate services provided by the waterways, and to introduce better transport into those areas where canals had not penetrated. Once again we find that private enterprise was responsible, and the result was a haphazard growth almost completely devoid of plan or any suggestion of a possible national system. Fortunately, however, with one major exception, the companies all adopted the standard gauge of 4 ft. $8\frac{1}{2}$ ins. The exception was the old Great Western which used a broad gauge until the 'nineties. Parliament, moreover, did all it could to promote competition and prevent any line from having a monopoly of traffic. Railways in Britain were regarded as dangerous innovations, to be resisted alike by turnpike trusts, canals, and landowners, and the result was that

from their very beginning they were hampered by excessive costs—heavy legal expenses in order to overcome opposition to the passing of their bills, and exorbitant charges for land.[1] To a certain extent the initial over-capitalisation thus entailed has been a burden to the railways ever since.[2]

To an even greater extent than that of the canals, the early history of the railways is bound up with the coal trade. Long before the invention of the locomotive, wooden, and later iron, tramways had been utilised in the Northumberland coalfield for transporting coal from the mines to Tyneside (*cf.* Fig. 149), and similar systems arose in Shropshire and in South Wales. The Tyne had for centuries been an avenue for coal traffic, and the increasing distance of the collieries from the river was not easily bridgable by canals, owing to the nature of the land surface. In South Wales, too, away from the main valley bottoms, canals were virtually impossible, and thus an extensive system of tramways grew up around Merthyr Tydfil and between that town and Cardiff. Between 1801 and 1825, when the first real "railway" was opened, no less than 29 "iron railways" were constructed in various parts of the country, mostly connected with canals, iron-works, or collieries.

The influence of the coal trade upon the early railway system may be gauged from Fig. 270.[3] The Stockton and Darlington line, the first public railway, was intended to provide an outlet for coal from Witton Park to the Tees, and its promoters had no intention of carrying passengers. A network of lines quickly developed in the north-eastern area, linking the collieries with the mouth of the Tyne and with the ports of Sunderland, Hartlepool, Stockton, and Port Clarence. In the Scottish lowlands the earliest lines (Monkland and Kirkintilloch; Glasgow and Garnkirk) were built to connect the Lanarkshire coalfield with the Forth and Clyde canal and with the port of Glasgow; in South Wales the Llanelly railway and the Taff Vale lines were likewise developed to facilitate coal movement; and the Leicester and Swannington line was designed to carry coal from the Leicestershire coalfield to the county town at a cheaper rate than that charged by the Soar navigation from Derbyshire. In Lancashire the inability of the existing system of waterways to accommodate the vastly increased traffic between Liverpool and Manchester engendered by the cotton industry was mainly responsible for the step taken by a group of merchants in promoting the

[1] The London and Birmingham, for example, paid £72,868 in legal costs, and an average of £6,300 per mile for land. See Pratt, *History of Inland Transport*, Chapter XX. Also H. G. Lewin, *The Railway Mania and its Aftermath*. London, 1936.

[2] It must be remembered, however, that these high costs really ceased before half the mileage was constructed, and the present high capitalisation is as much due to subsequent expenditure upon widening the lines to meet traffic growth.

[3] See H. G. Lewin, *The British Railway System* (to 1844). 2nd Edition, 1925.

Liverpool and Manchester railway, opened in 1830, but several subsequent lines had as their main object the improvement of the coal trade (*e.g.* the Wigan Branch railway).

In the 'forties the nucleus of the subsequent Midland Railway began to appear. This series of lines (Midland Counties, Rugby–Leicester–Derby; North Midland, Derby–Chesterfield–Leeds; Derby and Birmingham junction) had as its main object the improvement of Derbyshire coal trade—and it is interesting to note in this connection the way in which the subsequent Midland Railway, with the same intention, extended long tentacles to all parts of the country, its powers extending as far as Yarmouth, York, Carlisle, Liverpool, Bristol, Bournemouth, Swansea, and Southend.

Many of the early railways, as we have seen, were primarily coal

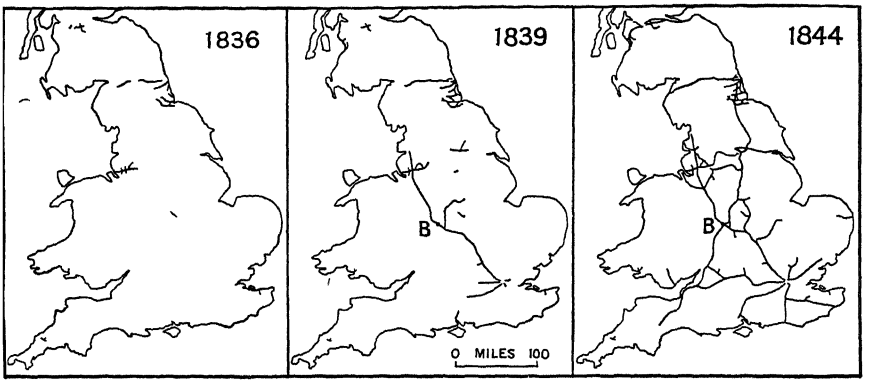


FIG. 270.—The growth of the British railway network

B = Birmingham. The two curious outlying lines, Bodmin–Wadebridge (Cornwall) and Canterbury–Whitstable (Kent) are interesting. The former was constructed to carry shelly sand from the Camel estuary to the agricultural lands around Bodmin; the latter to carry coal to Canterbury owing to the silting of the river Stour

carriers; passenger transport was a subsidiary business. It soon became apparent, however, that except in the colliery districts of Northumberland and Durham, Lanarkshire, South Wales, and South Lancashire—all of which were close to navigable water—the canals still held a great advantage in cheapness of conveyance, and that the railways would derive far greater benefit from the carriage of human freight. The second great object of the railway promoters was thus to link up the existing large centres of population with each other and with London, an object which, as Fig. 270 shows, was in an advanced stage of progress before the "mania" years. By 1844 through communication was established between London and Folkestone, Brighton, Southampton, Exeter, Bristol, Manchester, Liverpool, Preston, Birmingham, York, Leeds, and Newcastle; and the future importance of Birmingham and Man-

chester as junctions was foreshadowed. No less than three trans-Pennine connections were complete. The absence of the Great Northern line from these maps is an interesting reflection of the nature of the country through which that line afterwards passed—an extensive agricultural tract where there was little possibility of large local traffic.

The bulk of the mileage, then, until the "mania" years of 1845–1847, was dependent mainly upon passenger traffic for its revenue.[1]

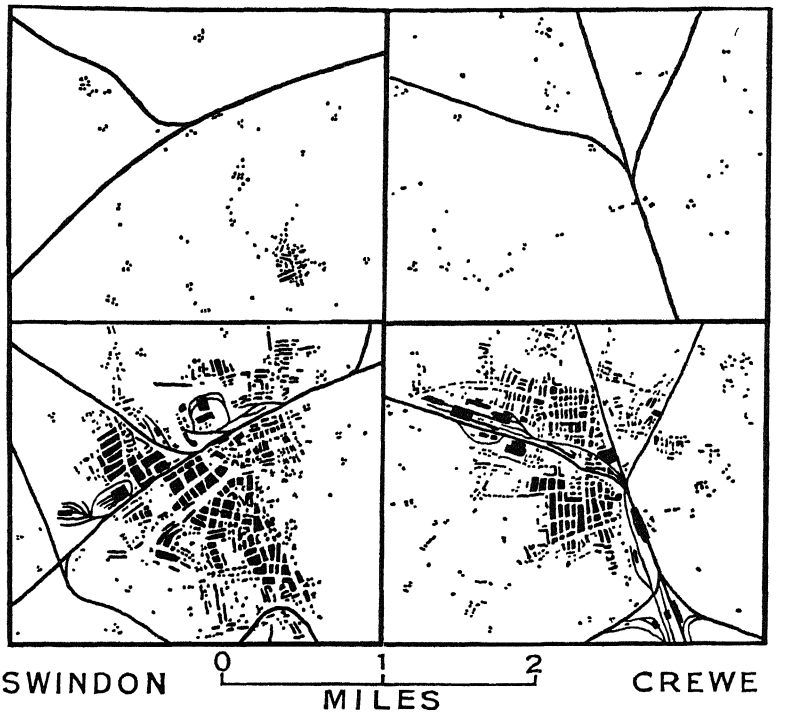


FIG. 271.—Two railway-created towns—Swindon and Crewe

The two upper maps show railways and buildings in the early 'forties; the two lower maps show the same features about 1920. In each case notice the railway works. Both towns have expanded considerably since 1920—Swindon to the east and north; Crewe to the south, south-west, and north-west

By this time the energy of the canal companies in trying to retain their traffic was beginning to wane, and from thenceforward goods traffic began to play an increasing part in the economy of the railways.

[1] To such an extent had the early objective of coal carrying been forgotten by some of the passenger lines that the following remark is probably representative of the more aristocratic attitude towards railways: "Coal!" a certain Mr. B. of the London and Birmingham is reported to have exclaimed when it was first suggested that his railway should carry so humble a commodity—"why, they'll be asking us to carry dung next!" (Acworth, *Railways of England*, p. 153.)

The subsequent history of the railway system is largely a story of development in hitherto neglected areas, and of amalgamations to form the great companies which existed before the grouping of 1921. We may profitably observe some of the geographical and economic consequences of that development. In the first place, the railways stimulated the growth of population and industries at their terminals and crossing points. Folkestone was the first railway-created port, but numerous others—*e.g.* Grimsby, Immingham, Middlesbrough, Fleetwood, Southampton, and the South Wales ports—were largely developed, if not actually created, by the forerunners of the railway companies which, before nationalisation, owner-operated them.

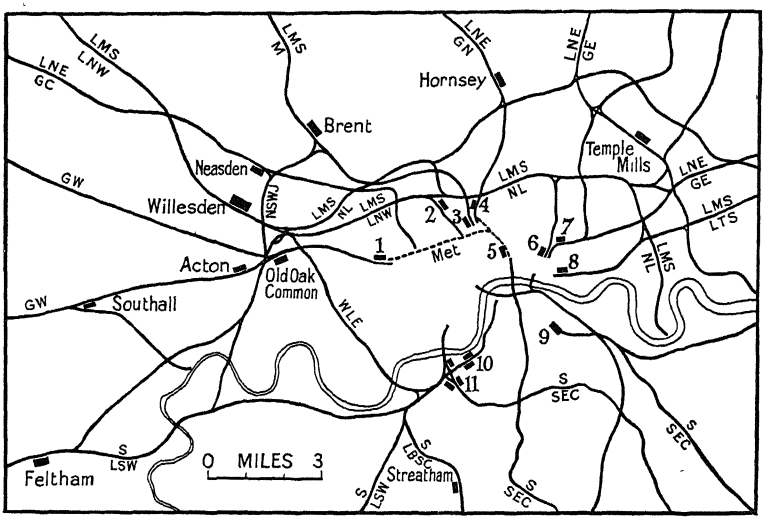


FIG. 272.—The radial lines and belt connections of London

The principal marshalling sidings are named; terminal goods depots are numbered 1–11
1, Paddington; 2, Camden; 3, Somers Town; 4, King's Cross; 5, Farringdon; 6, Broad Street; 7, Bishopsgate; 8, Fenchurch Street, 9, Bricklayers Arms; 10, Nine Elms; 11, Battersea

There are many examples, too, of towns which grew up at railway junctions. The outstanding examples are Crewe and Swindon (see Fig. 271). At Crewe, before the coming of the railway, not even a village existed; and the original Swindon was a tiny village on the top of an outlier of Portland stone over a mile south of the railway junction which lay in the clay vale beneath. In both these cases the growth was aided by the development of railway works. Ashford (Kent), Bletchley, and Rugby are other examples. At the crossing of rail and river the railway frequently gave a new lease of life to the decayed river ports—*e.g.* Lincoln, Gloucester, Chester, and Selby.

The power of the railway to attract commerce and industry was so obvious that towns which had not yet been reached pressed for

new lines, lest their development should be arrested. Not only did the railways help to concentrate industry on the coalfields by transporting raw materials to the fuel supply, but, by working in the opposite direction, they allowed the survival and renewed development of old industries in localities far removed from coal—as, for example, the engineering industries of the eastern counties. With the declining dominance of the coalfields as iron-producers the railways have also contributed to the scattering of industry over the countryside. In the development of the great conurbations the railways have been of prime importance. The vast daily movement

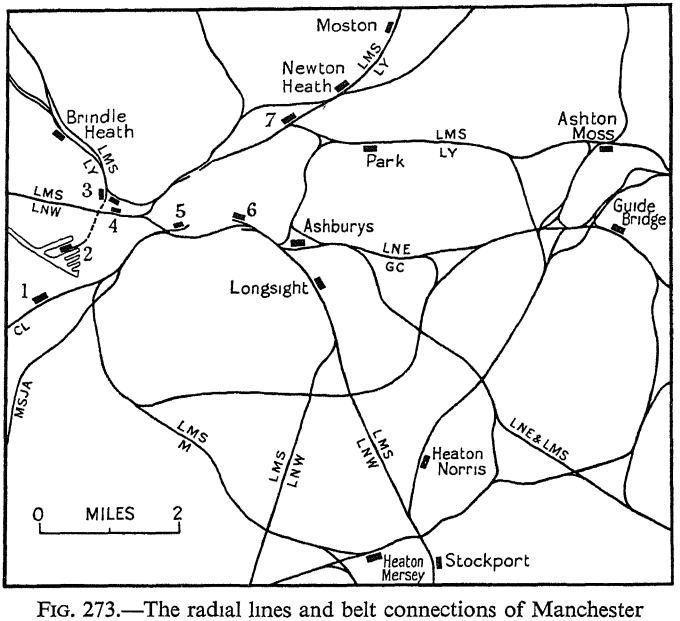


FIG. 273.—The radial lines and belt connections of Manchester

It is not possible to make the same distinction between suburban marshalling sidings and terminal goods depôts as in London. Nos. 2, 5, and 6 most nearly resemble the London terminal depôts Key to numbers 1, Trafford Park, 2, Salford Docks; 3, Hope St. and Windsor Bridge; 4, Liverpool Road; 5, Deansgate; 6, London Road, 7, Oldham Road

of passenger and goods traffic in these thickly populated areas would be impossible without the railway. The railway web of a conurbation is well worth examining. It consists essentially of radial lines with belt connections. The most symmetrical example is Paris, but London and Manchester (Figs. 272 and 273) may be taken as equally representative. In the case of London, the radial web is particularly well developed; but it is noteworthy that the belt connections are mainly situated on the north and north-west sides—for the obvious reason that most of the traffic arrives from the Midlands and North. The function of the North London line, from Acton and Willesden to Camden, Broad Street, and the Docks; of

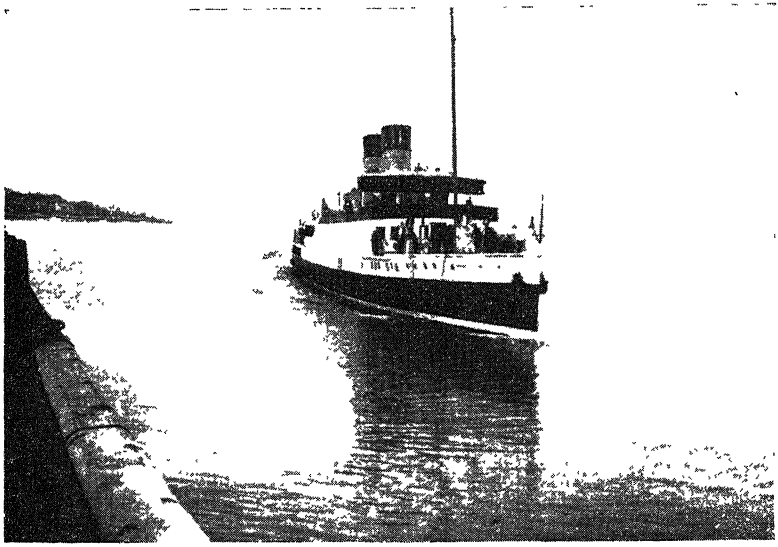
the North and South-west Junction line, from Cricklewood (Brent sidings) *via* Neasden and Willesden to the London and South-western line, and of the West London Extension railway, linking Willesden and Old Oak Common with the great Southern Region depôts at Battersea, should be specially noted. The distribution of the goods depôts is also interesting. These are of two kinds—the terminals, where the traffic is transferred to the markets or to road vans for distribution, and the marshalling yards in the suburbs near the belt lines. Fig. 273 shows that the same general plan can be detected in the case of Manchester—although here, as might be expected, the belt lines are mainly on the south and east (*i.e.* on the side of the great industrial regions of the Midlands and Yorkshire). The suburban railways of London pioneered in electrification—especially the Southern Railway—and by 1939 the Southern Railway had so extended its electrified lines on the third rail system as to have the largest suburban electrified network in the world. London led the world in electric 'tube' railways—unified as the 'Underground' under the London Passenger Transport Board with trams (which became extinct in 1952) and buses.

The part played by the railways in the development of holiday resorts has been of immense value both to the favoured towns and to the people who are thus enabled to visit them. Many a West of England fishing village was given a new lease of life by rail-borne holiday traffic, and a number of the foremost resorts, for example Bournemouth, Cleethorpes, Blackpool, and Clacton, were almost non-existent before the coming of the railways.

Lastly, the railways have frequently chosen somewhat barren and thinly populated sites for the establishment of huge marshalling yards where the traffic from many areas can be re-sorted and distributed. Such are Toton, on the edge of the formerly flooded Trent lowland between Derby and Nottingham (where most of the coalfield traffic is collected before being passed on to London and the South); March, only completed in 1932, a similar concentration point for the L.N.E.R.; South Crewe, at the junction of three main lines of traffic on the old L.N.W.R. (cf. Fig. 251), and Stoke Gifford, which collects Bristol and South Wales traffic on the G.W.R.

Two of the outstanding features of the British railway system are —or were, until 1939—the perfection of its permanent way (and consequent reputation for speed) and the small size, when compared with the Continent or the United States, of its rolling-stock. The former is largely due to the way in which the lines were originally built. In the first place, solidarity of construction was a policy carried to extreme degrees in order to satisfy those who feared for the safety of the trains; secondly, the early engineers were for the most part haunted by a fear that the locomotive would only run on level or nearly level lines, hence the extraordinary care taken, by

the provision of deep cuttings and tunnels and lofty embankments, to ensure the gentleness of the gradients.[1] Another legacy from the early days is a small loading gauge (*i.e.*, width and height of carriages and engines allowed)—from our pioneer experience of which Continental builders profited by employing a larger one—but full development under such conditions would have been difficult but for our excellent coal supplies. With fuel of high calorific value small fire-boxes and boilers can be employed on the locomotives; the engines of many Continental and American railways, burning inferior fuel or even lignite or wood, must needs have the ungainly



[*Photo. L. D. Stamp*

FIG. 274.—A railway-owned mail steamer approaching Dunoon

In western Scotland steamship services play a very important part in communications. Dunoon is the county town of Argyllshire—the second county of Scotland in order of size It is 28 miles from Glasgow as the crow flies, about 30 by steamer, but 80 by road (involving some stiff hills) and has no railway

heat-raising apparatus which makes them such monsters when compared with our own.

During the First World War, the railways were taken over temporarily by the State. It may be said that experience thus gained in unified working led to the consolidation of the numerous pre-existing companies into four great groups from January 1st, 1923—London, Midland and Scottish; London and North Eastern; Great Western; and Southern. Again, in the Second World War, the State took control and nationalisation as British Railways followed in

[1] See S. H. Beaver, "Geography from a Railway Train." *Geography*, XXI, 1936, 265–283

1948. The railways were organized in six 'regions' (Southern, Western, Midland, Eastern, North Eastern, and Scottish).

It remains in this chapter to call attention to the most recent trends in transport. Undoubtedly the extraordinary expansion of

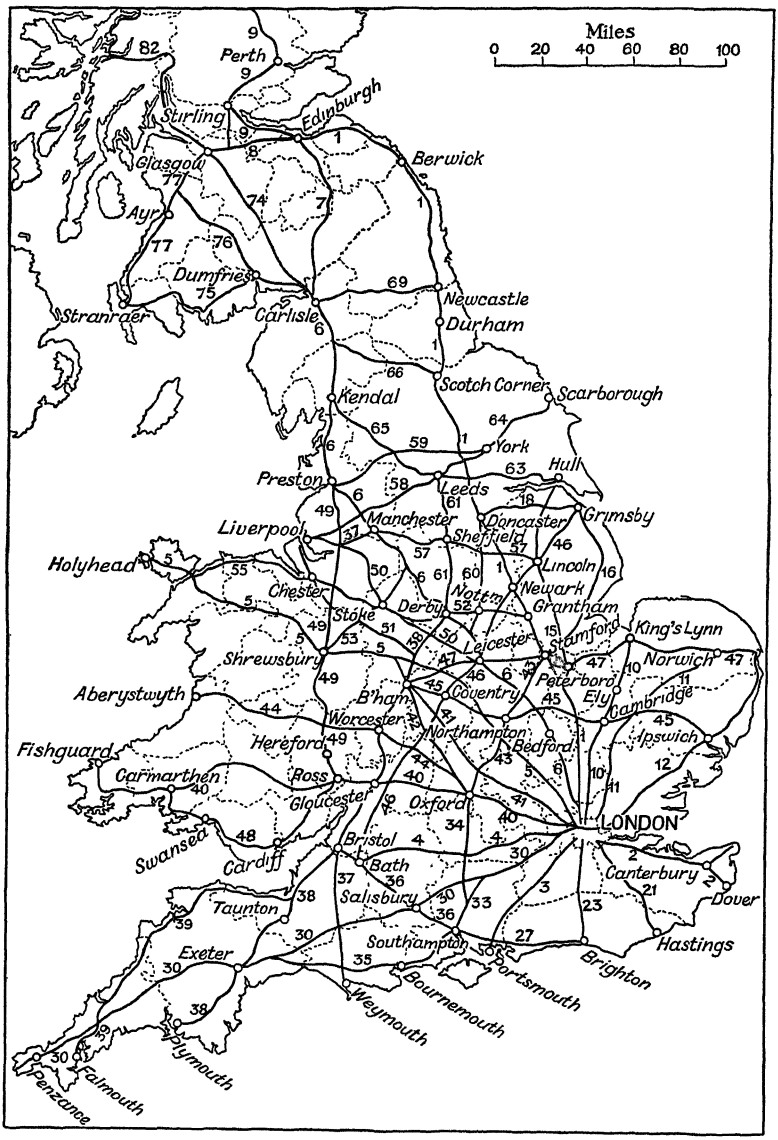


FIG. 275.—The modern roads of Britain, numbered according to the scheme of the Ministry of Transport. All are Trunk or A roads

bus services and of the road haulage of freight, during the last two or three decades, take pride of place, for internal air transport is not yet very highly developed. There are now very few villages in the country which are not reached by a public bus service of some sort, be it only on the local market day, and the resulting traffic patterns, which are at the same time emphasising existing urban nodalities and creating new foci, have been the subject of interesting investigations by F. H. W. Green (references on p. 652). Both passenger and freight services by road, using the public highway system, have seriously undermined the economic position of the railways. This is, of course, a world-wide problem by no means confined to Britain. But the vast increase in road traffic has not been accompanied, as in some countries, by a great reorganisation of the road system. A few by-passes have been built, and a few "arterial" roads leading out of the larger cities, but in general the roads remain much as they were before 1900, and the problems of traffic congestion, and the consequent danger to life and limb, are immense.

After the First World War the public roads of Britain were classified as 'A' roads, which were numbered, 'B' roads (likewise numbered) and C or unclassified roads. At a later date a small number of the chief A roads were recognised as trunk roads and their upkeep (except where they pass through large towns) became the responsibility of the central government. Otherwise the County is the highway authority. As part of national planning initiated during and after the 1939–45 war, a small number of new motorways is envisaged but restriction of use to motor traffic only will involve new legislation. A new road bridge over the Severn a little above Avonmouth has high priority among new schemes.

Civil aviation, largely perhaps owing to the comparatively small distances which can be covered in Britain, and to the necessity for auxiliary and time-wasting road services at the terminal cities connecting the landing-ground with the business centre, has not yet reached a stage of development comparable with that, for example, in the United States. It is true that airports have sprung up close to many of the principal towns (though some are undoubtedly "white elephants"), but air traffic cannot yet be said to have been popularised in this country for internal communications—though, of course, for international traffic it is an entirely different story, and such airports as Heathrow, Northolt and Croydon (London), Prestwick (Glasgow), Shannon (Ireland, Limerick), and Speke (Liverpool) are as busy as their equivalents in other parts of the world.

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CHAPTER XXVIII

THE SEAPORTS OF GREAT BRITAIN

THE first table given below illustrates two facts of outstanding importance. The first is the concentration of the huge trade of the United Kingdom in a few major ports. Thus the first six on the list handle three-quarters of the total traffic, or the first eight on the list more than four-fifths. Even more remarkable are the figures for the first two—London and Liverpool between them handling between 55 and 60 per cent. of the total foreign trade of the United Kingdom. The second point of importance is that this concentration of trade in the major ports has been a feature of the growth of British trade for a long time and, what is perhaps still more significant, it is still maintained, despite the temporary eclipse of London during the Second World War. The study of the development of British ports affords many interesting examples of the inter-relation of geographic and economic factors. In the first place it is true to say that the site of every British port was determined originally by local geographical conditions. The first requirement was the provision of a safe harbourage. In the second

I. TRADE OF THE LEADING PORTS EXPRESSED AS A PERCENTAGE OF VALUE OF THE TOTAL TRADE

Port	1913	1926–30	1935	1948
London	29·3	34·5	37·7	31·8
Liverpool	26·4	23·3	22·0	27·3
Hull	6·3	5·3	6·0	5·3
Manchester	4·0	4·7	4·3	5·6
Southampton	3·8	4·5	4·4	3·0
Glasgow	3·9	4·0	3·8	4·4
Harwich	2·4	2·5	2·0	0·7
Tyne ports	1·7	1·9	1·9	1·5
Dover and Folkestone	2·5	1·8	1·2	1·1
Bristol	1·5	1·8	2·0	2·9
Grimsby	2·7	1·7	1·4	1·0
Goole	1·3	1·3	1·1	0·8
Leith	1·6	1·3	1·1	0·8
Cardiff	1·7	1·1	1·1	0·8
Newhaven	1·5	0·7	0·6	0·4
Other ports, Gt. Britain	8·0	8·3	8·3	11·3
Northern Ireland	1·4	1·3	1·3	1·3

The first six (London, Liverpool, Hull, Manchester, Southampton, and Glasgow) 73·7 per cent. of the total in 1913; 76 3 per cent. in 1926–1930; in 1931 77·4 per cent.; in 1935 80·2 per cent.; in 1948 77·4 per cent.

Port	1913	1921–25 average	1926–30 average	1935	1948
London. Total	411 8	634·6	681 9	466 7	1,179·9
Imports	*253·9*	*423·3*	*470 4*	*321 4*	*673 2*
Exports	*99 1*	*139·1*	*148 1*	*112 2*	*483 2*
Re-exports	*58 8*	*72·2*	*67 5*	*33 1*	*23·5*
Liverpool. Total	370 8	541·5	460 6	271 8	1,091 6
Imports	*175 5*	*255·0*	*220·4*	*139 8*	*545 8*
Exports	*170 1*	*262·2*	*222·8*	*125·5*	*533 4*
Re-exports	*25·2*	*24·3*	*17·4*	*6 5*	*12 4*
Hull. Total	84·6	106·3	104·1	74·4	198 7
Imports	*49·8*	*69·0*	*71·4*	*48·5*	*127 0*
Exports	*29·2*	*34 3*	*31·2*	*24 8*	*64·6*
Re-exports	*5·6*	*3·0*	*1·5*	*1·1*	*5·1*
Manchester. Total	56·3	100·6	93·1	52·9	208·7
Imports	*35·3*	*60·9*	*63·0*	*39·8*	*138·6*
Exports	*20 6*	*38·5*	*29·4*	*12 8*	*69·4*
Re-exports	*0·4*	*1·2*	*0·7*	*0·4*	*0·7*
Southampton. Total	53·6	75·6	88·9	54·9	113·3
Imports	*25 5*	*35·2*	*40·6*	*26·1*	*53·5*
Exports	*20·7*	*30·7*	*37·2*	*23·5*	*57·4*
Re-exports	*7·4*	*9·7*	*11·1*	*5·3*	*2·4*
Glasgow. Total	54·8	85·8	79·5	46·7	162·5
Imports	*18·5*	*30·8*	*29·9*	*20·1*	*73·0*
Exports	*35·9*	*53·9*	*48·6*	*26 1*	*89·2*
Re-exports	*0·4*	*1·1*	*1·0*	*0·5*	*0·3*
Harwich. Total	34·3	38·4	48·4	25·0	25 8
Imports	*25·6*	*33·3*	*41·8*	*20·1*	*14·3*
Exports	*6·0*	*3·2*	*4·9*	*3·7*	*10·2*
Re-exports	*2·7*	*1·9*	*1·7*	*1·3*	*1·3*
Tyne Ports. Total	24·6	43·2	36·9	23·1	55 6
Imports	*11·4*	*19·0*	*20·9*	*11·6*	*29·2*
Exports	*13 2*	*24·0*	*15·8*	*11·3*	*26·1*
Re-exports	*0·0*	*0·2*	*0·2*	*0·1*	*0 3*
Dover and Folkestone. Total	35·2	42·1	35·3	15·6	41·2
Imports	*24 4*	*30·2*	*22·7*	*8·7*	*23·2*
Exports	*6·7*	*6·1*	*6·9*	*4 4*	*14·4*
Re-exports	*4 1*	*5·8*	*5 7*	*2 5*	*3·6*
Bristol. Total	22 1	38·8	35·0	24 6	108·4
Imports	*18·0*	*33·4*	*30 9*	*23·4*	*100·1*
Exports	*4·0*	*5 0*	*3·7*	*0·9*	*7·8*
Re-exports	*0·1*	*0·4*	*0 4*	*0 3*	*0·5*
Grimsby. Total	37·9	34·9	34·0	17 4	33·6
Imports	*15·9*	*16·5*	*21·6*	*12·3*	*20·5*
Exports	*21·9*	*18·3*	*12·0*	*5·1*	*11·3*
Re-exports	*0·1*	*0·1*	*0·4*	*0·05*	*1·8*
Goole. Total	18·8	28·0	25 8	13·1	28 1
Imports	*8·4*	*10·8*	*12 2*	*5 0*	*10 0*
Exports	*10 3*	*17 0*	*13 5*	*8 0*	*17·6*
Re-exports	*0 1*	*0·2*	*0 1*	*0 1*	*1·5*
Leith. Total	23 0	26·4	24·6	13·3	28·6
Imports	*15 8*	*19·1*	*19·0*	*10 1*	*22·4*
Exports	*6 9*	*6 9*	*5·4*	*3·1*	*6·2*
Re-exports	*0·3*	*0·4*	*0·2*	*0·1*	—
Cardiff. Total	23·9	31·6	22·5	13 1	29·0
Imports	*6·7*	*10·2*	*9·6*	*4 8*	*17·9*
Exports	*17·2*	*21·4*	*12·9*	*8·3*	*10 2*
Re-exports	*0·0*	*0 0*	*0 0*	*0·0*	*0 9*
Newhaven. Total	21·0	18·7	13·5	7·0	14 0
Imports	*13 5*	*13 8*	*8·8*	*3·2*	*10·2*
Exports	*5·0*	*3·6*	*3·5*	*2 2*	*3·3*
Re-exports	*2 5*	*1·3*	*1·2*	*1 6*	*0 5*
Other ports. Great Britain. Total	111 6	158·6	164·0	101·0	357·1
Imports	*53·3*	*74·0*	*86·2*	*49 3*	*181·4*
Exports	*57·8*	*82 4*	*74·8*	*49·9*	*166·1*
Re-exports	*0·5*	*2·2*	*3·0*	*1·7*	*9 6*
Ports of Northern Ireland Total	19·5	28·9	26·4	16·6	48·4
Imports	*17·3*	*21·9*	*18·7*	*11·8*	*36·7*
Exports	*0·7*	*6·4*	*6 6*	*4·1*	*11·4*
Re-exports	*1·4*	*0·6*	*1·1*	*0·7*	*0·3*
Total, United Kingdom	1,403 6	2,034·1	1,974·2	1,237·2	3,724·5
Imports	*768·7*	*1,156·6*	*1,184·0*	*756·0*	*2,078·0*
Exports	*525·3*	*752·9*	*677·2*	*425·8*	*1,581·8*
Re-exports	*109·6*	*124·6*	*113·1*	*55·3*	*64·7*

Based on tables in *Statistical Abstract* for the United Kingdom

III. Export Trade of the Leading Ports Expressed as a Percentage of the Total Export Trade

Port	1913	1926–30	1935	1948
London	18·9	21·9	26·2	30·4
Liverpool	32·4	32·9	29 4	33·6
Hull	5 6	4·6	5 8	4·1
Manchester	4 0	4·3	3 0	4·4
Southampton	4 0	5·5	5·5	3·6
Glasgow	6 9	7·2	6 1	5·6
Harwich	1 1	0·7	0 9	0·6
Tyne ports	2 5	2·5	2·6	1·6
Dover and Folkestone	1·3	1·0	1·1	0·9
Bristol	0·8	0·5	0·2	0·5
Grimsby	4·2	1·8	1·2	0·7
Goole	2·0	2·0	1·9	1·1
Leith	1·3	0·8	0·8	0·4
Cardiff	3·3	1·9	2·0	0·6
Newhaven	1·0	0·5	0·5	0·2

IV IMPORT TRADE OF THE LEADING PORTS EXPRESSED AS A PERCENTAGE OF THE TOTAL IMPORT TRADE

Port	1913	1926–30	1935	1948
London	33·3	39·7	42·5	32·5
Liverpool	22·8	18·6	18 5	·26·4
Hull	6 5	6·0	6 4	5·1
Manchester	4 6	5·3	5 3	5·2
Southampton	3 3	3·4	3 5	2·6
Glasgow	2·4	2·5	2 7	3·5
Harwich	3·3	3·5	2 6	0·5
Tyne ports	1·4	1·8	1·5	1·4
Dover and Folkestone	3·2	1·1	1 2	1·1
Bristol	2·3	2·6	3 1	4·8
Grimsby	2·1	1·8	1·6	1·0
Goole	1·1	1·0	0 6	0·4
Leith	2·1	1 6	1 3	1·1
Cardiff	0·9	0 8	0·7	0·9
Newhaven	—*	—*	—*	0 4

* Not available

V. ENTREPÔT OR RE-EXPORT TRADE OF THE LEADING PORTS EXPRESSED AS A PERCENTAGE OF THE TOTAL ENTREPÔT TRADE

Port	1913	1926–30	1935	1948
London	53·7	59·7	59·9	36·3
Liverpool	23·0	15·4	11·8	19·1
Hull	5·1	1 3	2·0	8 0
Manchester	0·4	0 6	0·7	1 0
Southampton	6·7	9·8	9·6	3·7
Glasgow	0·4	0 9	0·9	0·5
Harwich	2·5	1·5	2·3	2·0
Tyne ports	0 0	0·2	0·2	0 5
Dover and Folkestone	3·7	5·0	4·5	5·8
Bristol	0·1	0 4	0·5	0 8
Grimsby	0·1	0 4	0·1	2·7
Goole	0·1	0 1	0·1	2·3
Leith	0·3	0·2	0·2	—
Cardiff	0 0	0 0	0·0	1 4
Newhaven	2·3	1·1	2 8	0·8

place the situation of that safe harbourage or anchorage relative to important parts of the country and the ease of communication therewith played a leading part. Perhaps the first great test of the suitability of an existing port in relation to changing conditions came with the development of inland transport and the Industrial Revolution—the canal era and the concentration of industry on the coalfields—and then again later with the developments of the railway age. Where the port was so situated that it could utilise to the full these new means of communication it survived and

VI. THE LEADING BRITISH PORTS. SHOWING NET TONNAGE OF VESSELS CLEARED (MILLIONS OF TONS)

Port	1913		1926–30		1935		1952	
	Foreign	Coastal	Foreign	Coastal	Foreign	Coastal	Foreign	Coastal
London	11·4	8·6	19·4	7·9	19·5	7·8	18·5	11·1
Liverpool	11·2	4·2	13·0	3·5	12·5	2·7	12·7	3·8
Hull	4·4	1·4	4·4	1·3	4·5	0·9	4·3	1·6
Manchester	1·5	1·2	3·0	1·0	2·9	0·3	3·4	—
Southampton	6·6	1·6	10·4	1·5	10·7	1·8	13·8	4·1
Glasgow	4·3	2·0	4·8	1·5	4·4	1·5	4·9	1·8
Harwich	0·9	0·3	2·3	0·1	2·8	0·1	3·2	—
Tyne Ports	8·5	3·4	7·4	2·2	5·9	4·2	3·7	4·4
Dover and Folkestone	3·2	0·3	2·8	0·2	4·0	0·4	4·5	—
Bristol	1·1	1·6	2·0	1·3	2·1	0·9	2·3	2·1
Grimsby	2·8	0·3	2·0	0·3	1·8	0·4	1·5	—
Goole	0·8	0·7	0·7	0·4	0·6	0·5	—	—
Leith	1·5	0·8	1·5	0·7	1·3	0·8	0·6	0·4
Cardiff	10·4	2·2	7·0	1·2	5·3	3·3	2·2	1·8
Newhaven	0·5	0·2	0·6	0·1	0·7	0·2	0·5	—
Swansea	2·8	0·6	3·2	0·6	3·2	1·1	4·3	1·5
Blyth	2·2	0·3	1·3	0·9	1·2	2·1	0·5	2·1
Plymouth	3·8	0·9	6·3	0·5	5·2	0·5	1·7	—
Middlesbrough	2·1	1·3	2·4	0·8	2·1	1·1	2·9	0·7
Holyhead (and Beaumaris)	0·0	1·5	1·4	0·7	1·3	0·6	1·4	—
Cowes and Isle of Wight	0·0	1·9	2·0	2·1	3·8	2·9	—	4·2
Portsmouth	0·1	1·6	0·2	2·0	0·1	2·3	—	2·8
Sunderland	2·0	1·5	1·4	1·5	1·1	1·9	—	2·0
Belfast	0·3	3·1	2·5	2·9	3·2	3·8	0·7	5·2
Newport (Mon.)	—	—	—	—	—	—	1·7	0·5
Lancaster	—	—	—	—	—	—	0·7	1·2
Falmouth	—	—	—	—	—	—	1·7	—
Other ports	—	—	—	—	—	—	7·9	24·5

This table deserves careful study and comparison with those on preceding pages because it brings out the importance of coastal traffic apart from foreign trade and of certain purely "passenger" ports. Notice the large proportion of coastal trade still handled by the other small ports not named. Dashes indicate figures not available—usually unimportant.

expanded. But a still greater test was still to come. Could the port adapt itself to the increasing size of the modern steamship? A harbourage of limited size, a rock-girt basin, a river channel given to silting or difficult and expensive to dredge: these are factors which have resulted in the downfall of once significant ports. Whatever their original advantages, all the great modern ports have had to adapt themselves to changing conditions. Two factors are absolutely essential to this development. The first is the suitability of the site to adaptation, the second the existence of sufficiently wealthy or powerful interests to carry out the actual work of organisation and construction. The one, it should be noticed, is useless without the other. It is significant how often the geographical factor which originally rendered the site of value or of importance as a port, as, for example, the existence of a small safe anchorage or pool at Liverpool and Hull, has become, with the changing requirements of shipping, of very little importance, and it has passed both out of existence and out of knowledge. It will be useful therefore to sketch very briefly indeed the history of each of the major ports of Great Britain.

LONDON [1]

There is little doubt that London was a port as soon as it was a settlement. Below the site of London the banks of the river Thames were low and marshy and unsuitable for building, and we have seen how the settlement grew up where firm ground approached sufficiently near to the river and where there was also a possible fording place. Those who know London at the present day find it hard to believe that the Thames was ever fordable in the neighbourhood, but one must remember that man in the last 2,000 years has consistently been chaining the river into a narrow channel, whereas in early times, especially over what is now the Surrey side around Southwark, the waters must have wandered over a very wide area, and have been correspondingly shallow. From the early settlement trackways radiated to different parts of the country both to north and to south of the river, and there can be little doubt indeed that the early inhabitants of London had their primitive boats on the river Thames and that London was, therefore, a meeting place of land and water routes and a port. We may go so far as to say that the history of the port of London falls into four stages:—

(*a*) The early period (to the Norman Conquest);
(*b*) The medieval period;
(*c*) The nineteenth century—the great dock building era;
(*d*) The modern period dating from the establishment of the Port of London Authority in 1908.

(*a*) *The Early Period.*—The estuary of the Fleet as well as the well-known Pool of London below London Bridge must have afforded excellent anchorage for ships, and there is certainly no lack of evidence that Londinium was an important commercial centre much frequented by merchants and trading vessels at the time of the Romans. These facts are recorded by Tacitus in A.D. 61. It was natural, therefore, that London should later become the chief town of the East Saxons, and that in the eighth century the Venerable Bede should describe it as a market of many nations whose traders came to it both by sea and by land. Later, London fell into the hands of the invading Danes from whom it was rescued by King Alfred the Great who, by encouraging the building of ships, helped materially the commerce of the port.

(*b*) *The Medieval Period.*—There seems little doubt that London benefited on the whole from the Norman Conquest, for it was brought into closer relationship with the then more advanced countries of Europe. Merchants from France and from Flanders.

[1] We are greatly indebted to Mr. C. F. J. Tomlinson, Chief Information Officer of the Port of London Authority, for invaluable help in revising this section.

as well as from more distant countries, came and settled in London and developed the city's foreign trade. The construction of the Tower of London by William the Conqueror illustrates the importance that was attached by the Normans to the stronghold. Even before the Norman invasion bands of German merchants had settled in what is now the area of Billingsgate, and it was from the descendants of these German settlers that the Hanseatic League developed. The centuries succeeding the Norman Conquest are marked especially by the development of the Hanseatic League (which had its headquarters where Cannon Street station now stands) and by the stranglehold which it gradually obtained over the commerce and shipping of the port of London. With the discovery of America by Columbus in 1492 the great age of exploration began. As early as 1505 the Merchant Adventurers was incorporated, and this association of Englishmen rapidly became a great band of merchant shipowners as well as trading adventurers. The English merchants rapidly became so strong that in 1598 the Hanseatic League was expelled from the country by Queen Elizabeth. The sixteenth and seventeenth centuries witnessed a great development of English foreign trade and with it the development of the trade of the port of London. The Russian Company, the Turkey Company, the East India Company, the Hudson's Bay Company and other concerns came into existence during this period, particularly under the stimulus of promises of monopolies to those companies which first opened up communication and trade with new or undeveloped countries. There is no doubt, too, that London benefited by the sack of Antwerp in 1585, since Antwerp was at that time the centre of European trade, and one is justified in saying that from that event onwards London became the commercial and financial centre of the world. During this time London was a great river port. The small ships were beached or anchored by the side of the stream and their cargoes off-loaded in that position. Later it became desirable or necessary to construct small wooden piers or wharves of stone and wood at which the vessels could lie to be discharged or loaded. The sites of some of these early quays are still marked by quays used for the off-loading of goods, particularly the well-known Queenhithe and Billingsgate. Queenhithe—on the north bank above Southwark Bridge and so, like the Fleet anchorage, some distance above London Bridge, was probably the first wharf to be built. Old London Bridge played an important part in limiting the activities of the port. Every one must be familiar with pictures of the bridge with its double line of shops and houses and its numerous narrow arches. The rush of water through the narrow arches, both with the flow and ebb of the tide, was so severe that navigation was virtually limited to small boats and then to short periods of the day when the water

was comparatively slack. Thus the port developed below London Bridge, and it is significant that all the great docks of the Port of London to-day are in the area below London Bridge. London Bridge is, indeed, the head of ocean navigation (except for colliers and craft of comparable size up to about 1870 gross tonnage able

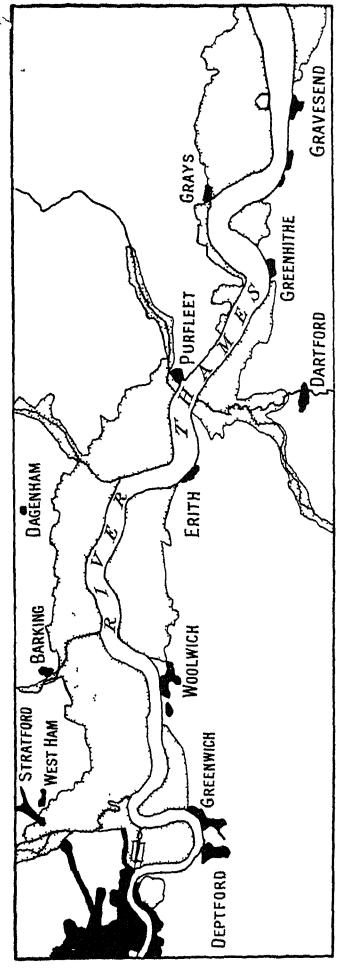


FIG. 276.—Riverside settlements on the Thames below London in 1802

The stippled area is the alluvial flood plain—practically without any habitations at this date All the riverside settlements were on bluffs where firmer rocks reached the river side

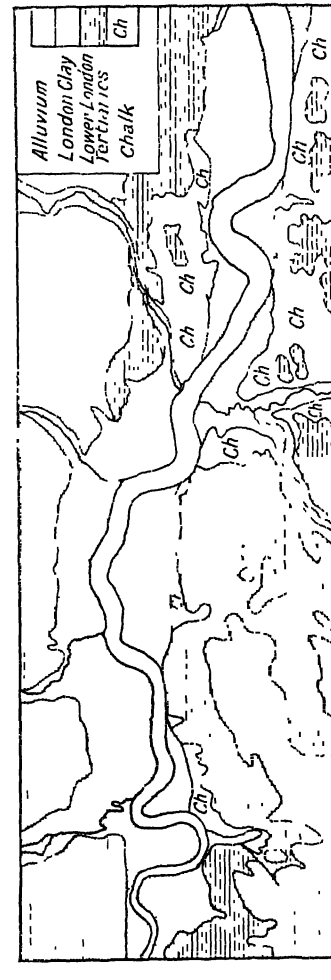


FIG. 277.—The geology of the Thames Valley below London

Comparing this map with Fig. 276 it will be seen that the majority of the early riverside settlements are where the chalk affords firm ground

to pass under the arches of the bridge) on the Thames to-day just as it was 500 years ago. The Great Fire of London in 1666 destroyed most of the wharf and warehouse accommodation existing up to that time, and the reconstruction was on improved lines. The quays built were of two types: the legal quays where loading and discharging were permitted only in daylight under

conditions enforced by the Commissioners of Customs and the sufferance wharves established by occasional licence to relieve congestion at the legal quays. It was during the eighteenth century that the greatly increased trade of the port of London demonstrated the insufficiency of the accommodation then available. Continuous congestion of shipping in the river itself resulted in great delay, loss, and inconvenience. It was difficult to protect vessels lying at anchor in the stream from plunder and from smuggling, and smuggling assumed huge proportions. Although a committee was appointed by Parliament in 1796 to inquire into methods of improving the port, it was the West India merchants who drew up practical proposals for the improvement of conditions. They laid it down as an axiom that any future development of the port depended upon the construction of wet docks.

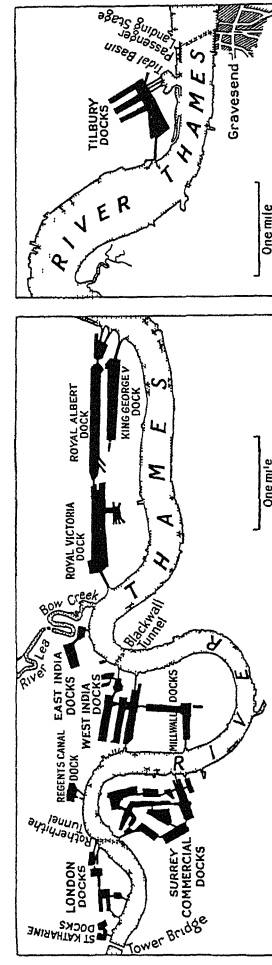


FIG. 278.—The docks of the Port of London
Comparing this map with Figs. 276 and 277 it will be seen that all the docks have been excavated in the previously uninhabited flood plain in the tracts of alluvium

(*c*) *The Nineteenth Century.*—There was thus initiated the great period of development in the nineteenth century which may be described as the dock building era. The scheme of the West India merchants was to construct two docks on the Isle of Dogs. The plan was sanctioned by Parliament, and the West India Docks were opened on August 27, 1802. They were the first docks as understood today to be opened in the port of London. The Howland Dock at Rotherhithe had been opened in 1696, but it was only intended for the safer anchorage of ships and, indeed, trees were planted as far as possible all round it in order to break the force of the winds. What had previously been regarded as the curse of London was now to be its salvation. For below the site of London, stretching practically to the sea and to a large extent along both banks, were enormous stretches of useless marshland, unsuitable alike for settlement and building, and for reclamation by the agriculturalists;

this land for the most part had been lying entirely waste. Thus there were huge tracts where enormous docks could be constructed. Further, the land was a soft alluvium easily excavated, and below that gravel and London Clay[1] which also presented little difficulty. The land to start with was at river level. The London Clay did not present difficulties in the construction of docks which a very pervious substratum might have done; but at the same time the solid clay was sufficiently firm for the foundation of quays and warehouses and, later, for great buildings such as flour mills. The London Dock was opened in 1805, the East India Dock in 1806, the St. Katharine Dock in 1820, the Royal Victoria Dock in 1855, the Millwall Dock in 1868, and the Royal Albert Dock in 1880. That curious collection of docks, now known as the Surrey Commercial Docks, came into existence piecemeal between 1807 and 1876. At a later stage came the construction of what is really the outport of London, Tilbury Docks, which were opened in 1886. In addition to the docks there were numerous riverside wharves and warehouses. The docks, warehouses, and wharves were built and owned by different companies. There was little co-ordination; instead destructive competition was the usual rule. Companies found themselves with insufficient resources to carry out the improvements and reconstruction which the growing size of steamers demanded. Towards the close of the nineteenth century there was a very real danger that London might pass into the position of only a second-class port.

(*d*) *The Modern Period.*—But the danger passed, when, it is true, after a considerable delay, Parliament passed the Port of London Act in 1908. This act created a new authority, a public trust—the Port of London Authority—which was to take over and administer all the docks and the whole of the tidal portion of the river Thames between Teddington and a line about 70 miles to the east across the estuary. The P.L.A., as it is usually called, has thus jurisdiction over the docks and their associated warehouses and storage yards, but on the main river itself the limit of the Authority's jurisdiction on both banks of the river is the high-water mark. Thus there are numerous quays and wharves lining the river which are privately owned, the best known of which is perhaps Hay's Wharf. In the river itself the duties of the Port Authority include all matters relating to navigation, regulation of traffic, and the maintenance of adequate river channels; and undoubtedly one of its most important works has been the improvement of the river channels. In 1909, just after the Port of London Authority took charge, the deepest draughted vessel that had used the Port of London up to that time drew 27 feet of water. Now vessels which draw up to 37 feet, the normal draught of the largest vessels in the world, can

[1] But chalk, not London Clay, underlies the alluvium at Tilbury.

use the Port of London. Fairly large sea-going steamers can ascend right to the Pool of London, to London Bridge.

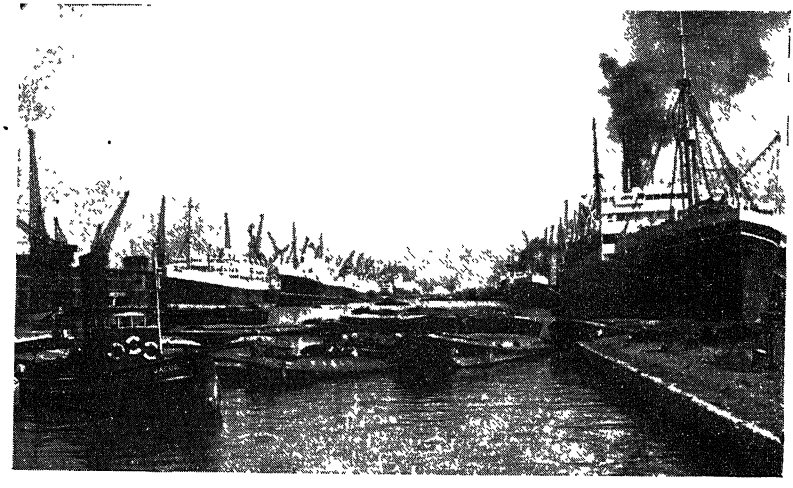
We can now proceed to examine some of the outstanding features of the Port of London. One of the most remarkable features is undoubtedly the extensive use of lighters or barges. Despite the enormous area of wharfage accommodation, something like four-fifths of all the cargo reaching the Port of London is off-loaded into lighters or barges, of which there are about 7,000 on the waters of the Thames. The owners of these lighters or barges still have the rights which were given to their predecessors when the first docks were sanctioned by Parliament. They can enter or leave any of the docks belonging to the Port of London Authority and remain free of dues for 72 hours, if engaged on bona-fide business. They are continually plying between the docks and wharves and the factories which line the 140 miles of banks of the river Thames. Most of these barges are towed by steam tugs. Only a few of the old sailing barges remain, whilst a comparatively small number are self-propelled. Although coal can be delivered by colliers of moderate size which are able to pass under London Bridge to such points as the Battersea Power Station, many riverside works above London Bridge depend upon the continued use of the barges. In the second place London illustrates remarkably well that the successful modern port must not only be well equipped for handling all types of general cargo, but must have the special equipment necessitated by special types of cargo. It is one of the features of the London docks that there is marked specialisation in the cargoes handled by the principal docks. Then there is no doubt at all that the Port of London derives an enormous benefit from its huge storage accommodation, for it enables the Port of London Authority to act as warehouseman, more especially of goods which are subject to heavy customs dues. Merchants and wholesalers can rent storage space in the Port of London Authority's warehouses, or can pay so much for the storage of goods, and thus defer the payment of customs duty until the goods are actually required and can be cleared. Thus enormous quantities of tobacco are normally stored. Further, there are facilities for the cold storage of meat and other commodities requiring very specialised storage conditions unrivalled by any individual firm. For these reasons London had formerly a virtual monopoly of several types of imports into the country, such as tea and rubber. The destruction of warehouse accommodation, however, has lowered London's share in the entrepôt trade of Britain from 60 per cent. to under 40. The table at the top of the next page shows the percentage of different imports into the United Kingdom which were handled by the port in 1929 and 1948.

The Surrey Commercial Docks deal with the greater part of the still largely seasonal timber trade. Storage accommodation is

	Per cent. 1929	1948		Per cent. 1929	1948
Meat	48	55	Tea	93	63
Grain and Flour	24	25	Non-ferrous metals	38	8
Cotton	1	—	Iron and steel	22	5
Wool	45	37	Hides and skins	43	19
Butter	44	46	Paper	50	47
Wood	31	37	Eggs	40	35
Crude mineral oil	50	10	Tobacco	30	23
Vegetable oils	35	39	Rubber	80	44

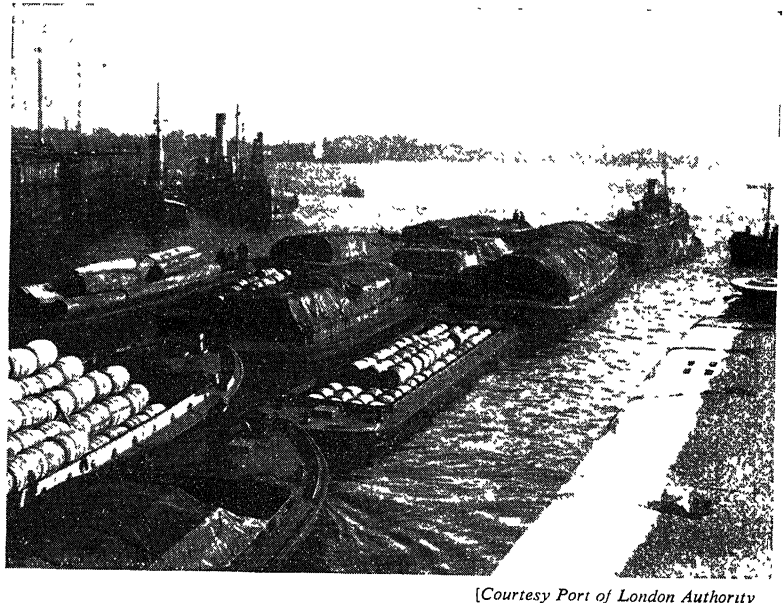
The drop in the proportion of crude mineral oil reflects the great development of refineries elsewhere (see p. 566)

provided for nearly half a million tons, and there were, until bomb damage, now being repaired, specially constructed sheds covering seventy acres, where timber could be seasoned, and, in addition, ponds for floating. The London and St. Katharine's Docks are those situated just below Tower Bridge—that is, nearest to London Bridge. As they are small, without direct rail connections, cannot be extended and cannot be used by the largest vessels, they are concerned mainly with coastwise and continental including Mediterranean trade, and are frequented by vessels up to 2,500 tons in gross tonnage. The storage arrangements here have been specially made for the more valuable types of merchandise such as wine, spirits, spices, sugar, ivory, gums, and essences. Farther downstream there is the great loop of the river Thames which almost cuts off the once pastoral marshy area known as the Isle of Dogs. It was only in 1929 that the two separate series of docks, the West India and the Millwall, which occupy this area, were united. The West India Docks, the oldest docks of the Port of London, were constructed specially for handling cargo from the West Indies; and it is remarkable that more than a century and a half later the most important commodities dealt with at the West India Docks still come from the West Indies. Here it is interesting to note other functions carried out by the Port of London Authority. Until rationing and Government bulk-buying were introduced during the Second World War, samples of sugar were taken by their experts, and the sales in the City were based on these samples which were in a way guaranteed by the independent and unbiased Port of London Authority. Hardwood is another of the commodities handled by the West India Docks. The Millwall Dock specialises in the handling of grain, and it is here that the grain is sucked from the holds of vessels by pneumatic elevators and passed into the central granary, which with a capacity of 24,000 tons holds sufficient grain for London's needs for at least a week. Farther downstream the East India Dock formerly handled large quantities of goods from the East, particularly tea and silk; but now deals only with small coastwise and near continental traffic. At Royal Albert Dock special arrangements have been made for the banana



[*Courtesy Port of London Authority*

FIG. 279.—Unloading in the Royal Docks, Port of London



[*Courtesy Port of London Authority*

FIG. 280.—Loaded lighters being towed out of the Royal Docks

traffic of London. Here, too, there is a disease-proof quarantine station established for pedigree stock for export to various parts of the world. The Royal Victoria, Albert, and King George V Docks

are in reality one huge dock divided into three sections. They form the largest sheet of enclosed dock water in the world, with a total area of 1,100 acres, of which 245 acres are water, and with 11 miles of quay. In these docks the water is kept at a height of 2½ feet above high-water mark. To the north of the Royal Victoria Dock are the storage warehouses, whilst to the south are four large flour-mills. The Royal Albert Dock handles most of the meat imported by London, much of the meat being taken into a huge cold store which has been erected to the north side of the dock, and which is capable of accommodating a quarter of a million carcasses of mutton. The King George V Dock was opened in 1921, and, with a depth of 38 feet, it can accommodate vessels up

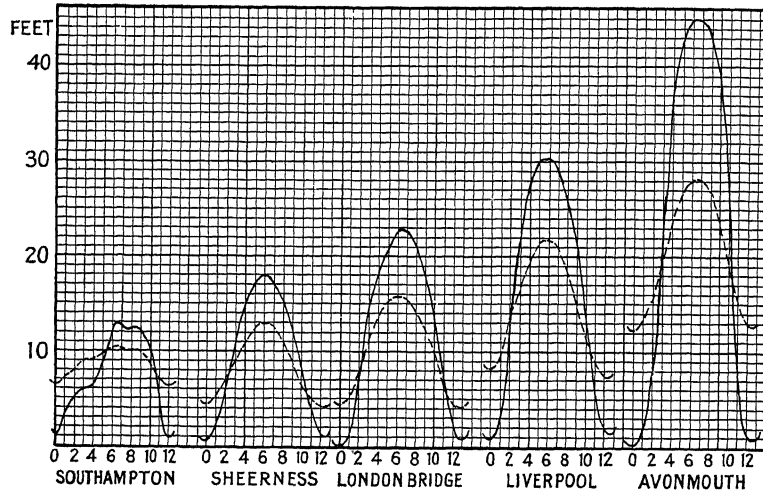


FIG. 281.—Tidal graphs of some characteristic British ports

The two graphs in each case are for a typical spring tide and a typical neap tide. Figures below show the time in hours. Notice the effect of the double tide at Southampton and the small range; the increasing tidal range in the Thames as one goes from Tilbury to London Bridge; and the enormous range at Avonmouth

to 35,000 tons gross (such as the Mauretania), despite the fact that it is comparatively near to the heart of London. Large vessels, such as the P. & O. liners of 28,000 tons can be accommodated in the Tilbury Docks, where an entrance 1,000 feet long and 110 feet wide was opened in September, 1929, and where a magnificent dry dock was later completed. Tilbury handles most of the passenger traffic using the port of London, and there is a floating landing stage which can be used at all stages of the tide. It is served directly by rail and is within 45 minutes of the heart of London in addition to having easy communication with all parts of the country. Although built by the combined East and West India Docks Company

Tilbury might have developed into a separate "outport" and rival of London itself, but the unification of control has prevented this.

Naturally the docks of London were a priority target for enemy bombing from 1940 to 1945; destruction, especially of warehouse accommodation, was great and the port was virtually unused.

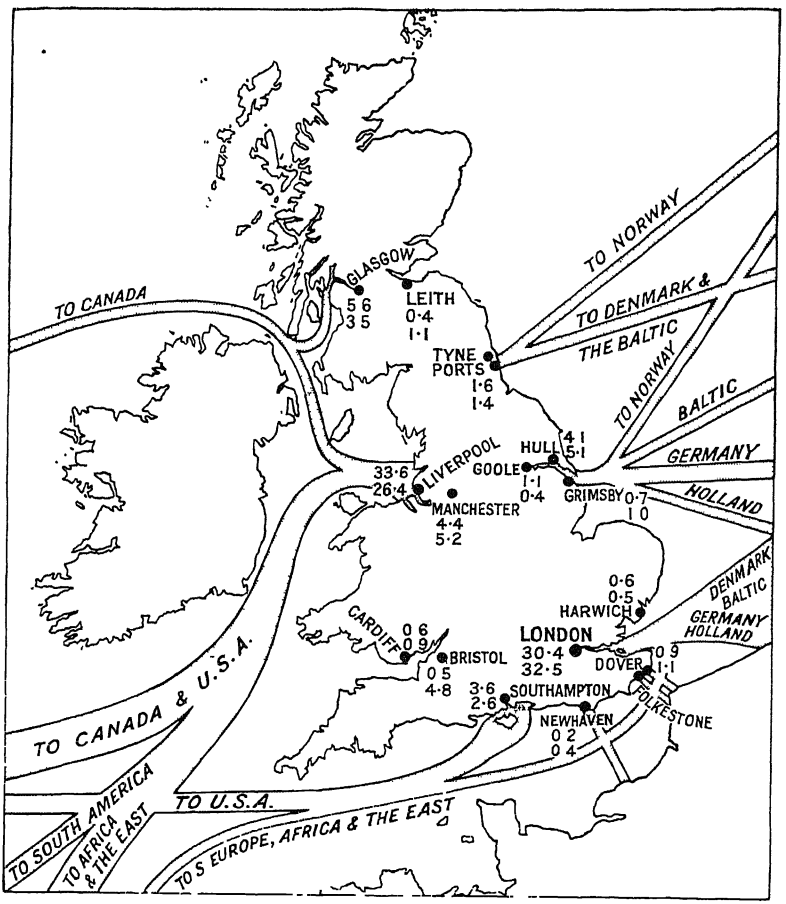


FIG. 282.—General map of the Ports of the British Isles showing the proportions of the total export trade (upper figures) and import trade (lower figures) handled by each in 1948

Some attempt is made to show the countries *principally* served by each port

But the main structures of the docks remained and they have been restored.

We have indicated elsewhere how the once significant shipbuilding industry of the Thames has disappeared, and London illustrates rather well the separation of shipbuilding from ship

repairing. The Port of London is very well equipped for ship repairing. It has no less than nine dry docks, including one at Tilbury which is 750 feet long and 100 feet wide and can, when the increasing size of vessels demands it, be extended to over 1,000 feet in length. In these docks every facility for the repair and overhaul of vessels is provided. One very important factor in the maintenance of London's pre-eminence as a port is the close co-operation between the port and the commercial centres of London. This is possible despite, in fact one might say because of, the separation of London into zones of functional utilisation. Thus going westwards from dockland one comes immediately to the commercial and business centre of London—first to the network of narrow streets where are situated so many of the wholesale firms. This juxtaposition is responsible for the retention in London of a great woollen market—for so long and to some extent even now a world market—despite the fact that practically none of the wool is used for manufacture in the neighbourhood of London itself. Then there is very close connection between the Port of London and industrial London. On p. 623 we have given a map showing the situation of so many of London's industries along the banks of the Thames and the still important canal systems.

LIVERPOOL AND MERSEYSIDE[1]

If London has been a great port for 2,000 years the same can scarcely be said of Liverpool; for the real rise to importance of Liverpool is within the last two hundred years. A thousand years ago, when London was already an important centre, Liverpool was just one of a group of small vills comprised within the ecclesiastical parish of Woolton in the Greathundred of West Derby. Both sparsely inhabited and comparatively unimportant was the region at the time of the Domesday Survey, hence (because of its unimportance) the hundred of West Derby is one of the largest in the country. The greater part of the old parish of Woolton was situated on an island-like upland, formed of Keuper and Bunter Sandstone, which the late Professor P. M. Roxby called the Liverpool Plateau. It was almost surrounded by low-lying land, originally "mosses" or low-lying peatland which cut it off from the rest of Lancashire. North-eastwards a ridge of slightly higher land connected this island-like site with South Lancashire through Prescot, and for a very long time the only carriage road lay along this ridge. To the south-west the plateau approached very close to the bottle-necked estuary of the Mersey. Liverpool was an

[1] Our thanks are due to Mr. W. E. Sutton, Public Relations Officer of the Mersey Docks and Harbour Board, for help with the revision of this section.

agricultural township, but it had the advantage of a small tidal creek called the Pool which extended inland for about half a mile from the site of the Customs House along the line of what is now Paradise Street and Whitechapel as far as the old Haymarket. King John seems first to have visualised the possibilities of Liverpool as a port for Ireland—a military port in that case—and so made it into a borough in 1207. And it was from the quiet waters of the Pool that fishing and coastal traffic was built up, including a not inconsiderable trade with Ireland. But in these early days Liverpool was overshadowed by the importance of Chester. Indeed, it was claimed as being merely a creek within the port of Chester. But, owing to the silting up of the Dee estuary which was specially marked from the fourteenth century onwards, Chester became unimportant as a port even before the rise of the trans-Atlantic trade which was destined to be of such significance to Liverpool. The great age of exploration initiated by the discovery of America in 1492 first gave Liverpool its real opportunity, but for long Bristol dominated in the western trade. There seems little doubt that the greater security of a route to the north of Ireland compared with the route to the south of Ireland was by no means unimportant in view of the long series of wars with Holland and France in the seventeenth and eighteenth centuries. Although the immediate situation of Liverpool rendered communication with its hinterland in Lancashire difficult, the importance of the Midland Gate which facilitated communication between the merchants of London and Liverpool soon came to be recognised. From the latter part of the seventeenth century the growth of the port was rapid. First came the recognition of Liverpool as the chief port for the Irish trade as far as the north of England was concerned, as well as for increasing coastal traffic with western Scotland. Then there was the rapid development of trade with the West Indies, unfortunately associated from about 1730 with what has come to be known as the great Trade Triangle and which dominated Liverpool shipping in the latter half of the eighteenth century. Ships from Liverpool sailed to West Africa with cheap manufactured goods such as beads, indifferent muskets, gunpowder, and raw spirits which they traded with the African slave-traders or so called "kings," who organised slave raids into the interior. These same ships then took on board full cargoes of negroes and made the famous middle passage with the help of the Trade Winds, disposing of the slaves in the West Indies, returning thence to Liverpool with a cargo of molasses, tobacco, and cotton. The abolition of the slave trade in 1807 did not, as many Liverpool merchants had anticipated, check the growth of the port. By that time the Industrial Revolution was in full swing, and there was a huge demand for raw cotton from the southern United States, and Liverpool became what it has since

remained—the chief importing port for raw cotton. Then came the development of trade in cotton goods, particularly after the cessation of the monopoly of the East India Co., as well as the development of more varied trade with the North American continent and an emigrant traffic.

Just as in the case of London, it was found that Liverpool was so situated that she was able to adapt herself to changing requirements. The mouth of the old pool was converted into a wet dock —one of the first in the world—and the remainder of the pool filled in. There was a marshy fringe running along the side of the Mersey and bordering the sandstone plateau on which the settlement was situated, and this afforded possibilities for the excavation of docks just as the marshy land of the lower Thames had done. The docks were extended all along the water front southwards until the natural limit was reached where there is an outcrop of sandstone on the river bank at Dingle Point. Here is the residential district of Aigburth. Beyond this, however, are more marshes, and here has been developed the group of docks forming the port of Garston owned, before the nationalisation of the railways, by the London, Midland and Scottish Railway. To the north of Liverpool the limit has not yet been reached, and here it was claimed that the Gladstone group of docks when opened was amongst the largest and best equipped in the world. But the development of docks along the whole water front has had two main results. The old shipbuilding yards have disappeared, and not only have the warehouses and mills been forced inland, but still more has industrial development. Few of the factories of Liverpool can be supplied direct from lighters as in the case of London or Hull, and so lighters play but a small part in the life of the port. Whilst the excellent arrangement in the port itself renders loading and off-loading possible in very short time, and the overhead railway running the length of the docks enables workers to get quickly to their work, the facilities for the development of industries are not correspondingly great. As in London the early dock construction was carried out by separate companies; but the need for a unifying authority was appreciated much earlier, and the Mersey Docks and Harbour Board came into existence in 1858. It now controls the whole dock estate on both sides of the river, except for the nationalised Garston docks which are under the Docks and Inland Waterways Executive. The rapid development of the whole water front of Liverpool rendered the utilisation of the Cheshire side inevitable, which happened in the middle of the nineteenth century —about the initial nucleus of Wallasey Pool, an inlet corresponding roughly in character with the old Liver Pool. There are now (1953) 460 acres of docks on the Liverpool side with a quay frontage of 27 miles, and on the Cheshire side a water area of 181 acres and

9 miles of quay. There is not as yet a continuous line of docks on the Cheshire side as there is on the Liverpool side, and so a considerable number of industrial concerns there have their own water frontage. There one finds also the shipbuilding yards, particularly those of Cammell Laird & Co. Thus, on the Cheshire side, there has grown up the great industrial and commercial town

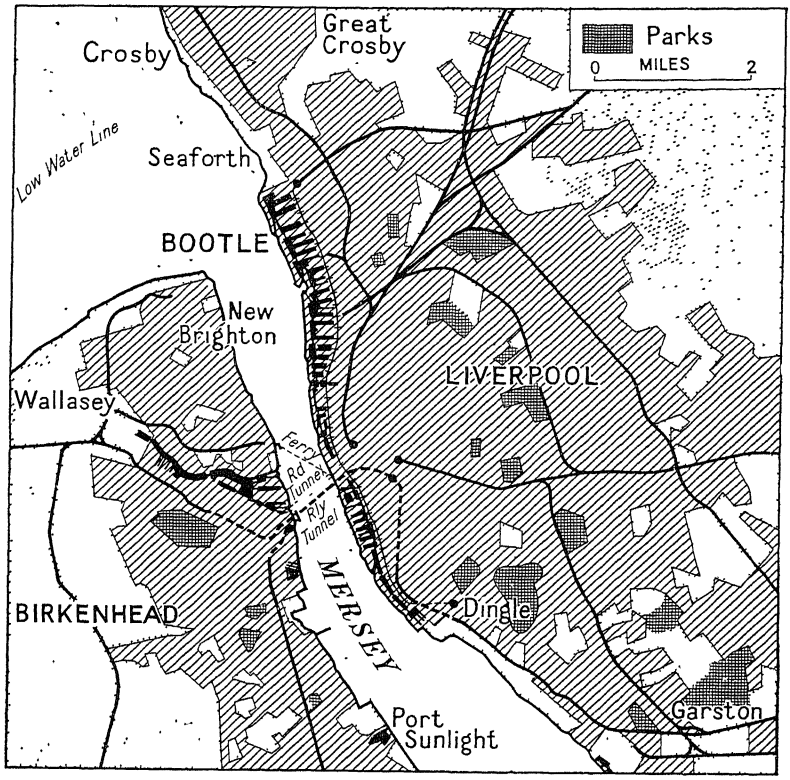


FIG. 283.—The port of Liverpool

A unique feature of Liverpool's transport system is the electric overhead railway, supported on wrought-iron columns about 20 feet from the ground It runs for 6½ miles alongside the docks, from Seaforth to Dingle, thus affording exceptional facilities for travelling from one part of the long dock estate to another It is shown above along the dock front The famous road tunnel, which cost over £7,000,000 and was opened in 1934, lies immediately to the north of the railway tunnel

of Birkenhead, and more recently the residential area known as Wallasey, which may fitly be described as a dormitory for both Birkenhead and Liverpool. Indeed the greater part of the Wirral Peninsula is rapidly becoming a residential area for Merseyside. Immense numbers of workers cross over morning and evening by ferry and by the Mersey railway from the Cheshire to the Lancashire

side, and the need for the construction of the Mersey road tunnel (opened 1934) became apparent.

It has been pointed out that the Liverpool plateau is separated from the main part of Lancashire by a belt of low-lying "moss." A large proportion of this is now extremely fertile agricultural land. Some of it is reserved in the form of parks which form the outer fringe of Liverpool. Both types of utilisation tend to emphasise the isolation of the Liverpool region from the manufacturing and industrial regions of south Lancashire. This isolation is borne out by the character of the industries of Merseyside. For the major industries are based essentially on imported materials—milling, soap, and candle manufactures, cattle-food industries, and so on. Liverpool shows to some extent the zoned character of London. In the rear of the docks there is the business part of the city, concentrated especially round the Town Hall and coinciding very closely with the centre of the old township. Near at hand is what may be described as the social centre with fine public buildings such as the Picton Library, St. George's Hall, the Walker Art Gallery, and many of the finest shops. Then, forming an irregular ring, is the residential area, some of it still consisting of extremely congested slums—a legacy of the early days of the Industrial Revolution which Liverpool has done her utmost to remove. It is on the high ground of the sandstone plateau that a great new cathedral is steadily rising and the University buildings are being multiplied. On the outer margins there is a ring of great public parks. The industrial development tends to be concentrated near a labour supply, and as far as possible near the supplies of raw materials from the docks. In some cases the industrialisation is considerably removed from the centre of the city, as in the Aintree district. On the Cheshire side lie two main areas of industrialisation. One is to the south of Birkenhead on low ground where the industrial area of Port Sunlight and the region around Bromborough Port has been spreading right to the entrance of the Manchester Ship Canal. The second area is on the Great Float, the lower part of Wallasey Pool, where the Mersey Docks and Harbour Board hold land for future development.

Like other ports Merseyside had its share of bombing and prepared its post-war plans. The conurbation faced several special problems. One is the need to prevent Liverpool spreading inland, both because of the very productive character of the farmlands, famed for their potatoes, and also because of the desirability of preserving some open land between Liverpool and the Mid-Lancashire towns. So a careful integration of industry, housing, recreational and farmland was planned for the Wirral Peninsula.

There has been some development of docks and industrial areas along Deeside, on the Flintshire or North Wales side of the Dee estuary, but this is rather isolated.

Liverpool–Birkenhead is associated with important shipbuilding and ship-repairing works as well as being the port of registration of much merchant shipping. The ships owned at, or sailing from, Liverpool provide employment for roughly a quarter of all the seamen of Britain, whilst Liverpool rivals Southampton as the premier passenger port of the British Isles, handling about 30 per cent. of the passenger traffic. About one million passengers embark or disembark annually. Amongst imports Liverpool handles a large proportion of the raw cotton.

PERCENTAGE OF U.K. IMPORT TRADE IN VARIOUS COMMODITIES HANDLED BY LIVERPOOL (1948)

	Per cent.		Per cent.
Meat	26·1	Non-ferrous metals	8·3
Grain and Flour	22·9	Iron and Steel	5·3
Cotton	84·0	Hides and Skins	61·5
Wool	40·3	Paper	3·7
Butter	11·6	Eggs	21·5
Wood	37·0	Tobacco	35·9
Vegetable oils	41·0	Rubber	48·0
Tea	25·3		

MANCHESTER

As an ocean port, Manchester only dates from January 11, 1894, when the Manchester Ship Canal, constructed between 1887 and 1893, was opened for traffic. The Manchester Ship Canal extends from Eastham on the south side of the Mersey to the heart of Manchester,[1] and has a total length of 35½ miles and a minimum depth of 28 feet. Docks at Eastham have been reconstructed to take tankers up to 30,000 tons though vessels of this size cannot go the whole length of the canal. The bottom width of the canal at the full depth is, with a very few exceptions, 120 feet. This is sufficient to allow large ships passing one another, and at the bend at Runcorn the bottom width has been increased to 155 feet. In Manchester itself, the Trafford Park Trading estate has developed adjoining the docks. In 1894, the first year that the port of Manchester was opened, the value of the trade was £6·9 millions sterling, of which about 40 per cent. represented imports. The trade had grown tenfold in value by 1929. The capital expenditure on the canal by the end of 1914 was nearly £17 million, and it was not until 1915 that the first dividend was paid on the preference stock. The canal links two of the busiest industrial regions of the British Isles, and eventually the whole 70 miles of its two banks may be lined with quays and factories. Marked development of industry has taken place at Irlam, notably iron and steel of the Lancashire Steel Corporation. The development of the port has not adversely affected

[1] Most of the docks are actually in Salford, but cf. p. 606

the development of Liverpool. One may even go so far as to say that it has acted as a safety valve. Only in the case of one or two commodities does the quantity landed at Manchester exceed that landed at Liverpool; of these one is petroleum—obviously destined for the refineries along the canal itself. Indeed, in 1948, Ellesmere Port near the entrance to the canal, received 16 per cent. of all the crude mineral oil imported into Britain and new refineries at Stanlow have extended the trade. Manchester still only handles a fraction of the quantity of raw cotton imported by Liverpool. It should be clear that the statistics for the "port of Manchester" include the whole of the canal.

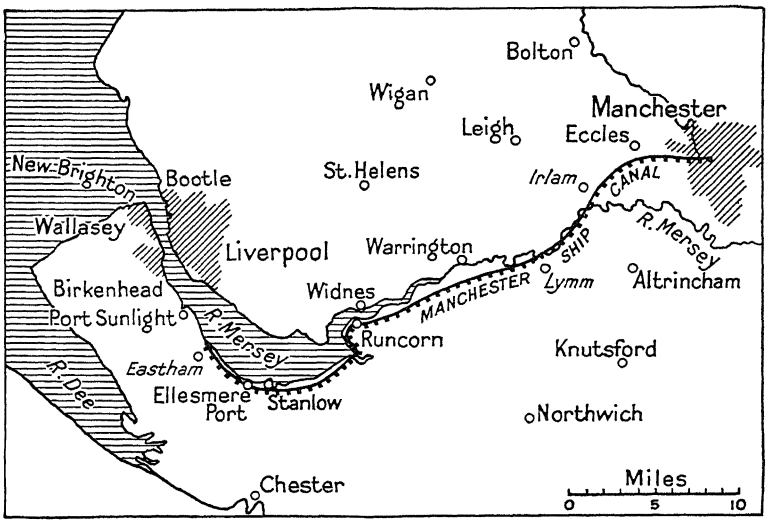


FIG. 284.—The Manchester Ship Canal

HULL

Hull is an example of a port whose commerce has been continuously active, and whose position in relation to other English ports has changed very little since the Middle Ages. In this respect Hull can be compared with London. Again, we have an example of a port where geographical surroundings permitted its adaptation to modern conditions—as in the cases of London and Liverpool. By way of contrast other ports of the vicinity were not so fortunate. In the thirteenth and fourteenth centuries the commerce of Boston, which was the outport of Lincoln, exceeded that of Hull, but is now entirely insignificant. The possibility of development was precluded for one reason by the silting up of the approaches to Boston. The port of Hedon flourished in the twelfth and thirteenth centuries

and stood, like Kingston-upon-Hull, on a tidal creek of the Humber to the east of Hull. But it was too far inland for the approach of modern vessels and suffered, again, from the choking of its channels. Finally, Ravenserodd, formerly situated on a small sandbank behind Spurn Point, entirely disappeared in the middle of the fourteenth century—a victim of the tidal scour which somewhat earlier had created the very land on which it was built.

The little river Hull enters the Humber from the north just where the line of the Humber curves northwards in such a way that the river current and the tidal current hug the shore and guarantee permanent deep water. The river Hull is navigable for some distance to the north, and, as is so frequently the case, near the head of navigation a small port and town sprang up—the town of Beverley—situated some distance away from the marshy banks of the river itself with which it is connected by an artificial channel. The first stage in the history of the rise of the port of Hull was when the little creek offered shelter or anchorage for boats on their way to its older neighbour Beverley. A little marsh-surrounded settlement grew up to the immediate west of the mouth of the creek, and it was Edward I who, in passing through this little settlement, caused it to be known as King's Town upon Hull (Kingston-upon-Hull is still the full name of the city of Hull), and granted the town its first charter. A plan of Hull dating from the fourteenth century shows a small settlement with quays on the east at which sailing boats are being unloaded with the help of hand cranes, and the settlement guarded on the north, west, and the south by a wall outside of which is a moat connecting the waters of the Hull with the waters of the Humber to the west of the settlement. A glance at a physical map will show that Hull is situated on the Humber a few miles to the east of the point where that river cuts through the chalk escarpment. To the west, the north-west, and the south-west lies the Trent and Ouse Basin: in all covering an area of about one-sixth of the whole of England. Most of the rivers of the basin were navigable for considerable distances. Doncaster was about three miles above the old limit of navigation of the Don and York lies near that of the Ouse. Thus, in early days, a place of shelter near the mouth of the Humber could not compete with the ports which were situated well inland along these navigable rivers.

The second stage in the development of the port came with the increasing size of ocean-going vessels. Hull became the point of trans-shipment for river craft trading with towns on the navigable parts of the Ouse and Trent system. It clearly had the advantage of position, and could fulfil this function in a way in which Beverley could never do. So Beverley gradually became what it is to-day—a small town constructing trawlers for the fishing industry of Hull. The appalling condition of roads in England gave Hull a very

considerable importance as an outlet from all central England, even for goods from such areas as Cheshire and Lancashire destined for London.

The third stage in the development of the port came with the canal era, when the natural waterways were improved by a network of canals, of which the Aire and Calder was, and remains, the most important, which brought the growing industrial centres, particularly of West Riding, into easy communication with Hull. Thus the outstanding features of the port of Hull to-day—especially the immense amount of trans-shipment into lighters for distribution—developed at an early date. Further, Hull is still unique amongst the ports of the British Isles in the extent and significance of inland water navigation from its docks.

The fourth stage in the development of the port came with the construction of docks. As Rodwell Jones has said, "the increase in size of vessels together with the increasing volume of trade made it necessary to supply means whereby ships could be in harbour for considerable periods without grounding, and cargoes could be dealt with at quaysides without change of level, since the tidal range at Hull is about 19 feet." The old wall and moat became the site of the earliest docks. The Queen's Dock or Old Dock was opened in 1778, Humber Dock in 1809, Princes or Junction in 1829. The coming of the railway is emphasised by the name Railway Dock—a small offshoot from the Humber Dock opened in 1846. The earlier line of approach to Hull by railway (from Selby, opened in 1840) followed along the Humber where there was sufficient space between the chalk scarp and the river to obviate the necessity of constructing a tunnel. A later line which approached the town from the north-west had to cross the chalk scarp; the gradients are considerable, and there is also a tunnel. Marshy, unoccupied land to the south-east of the town has provided further opportunity for the construction of docks, and there followed here the Victoria Docks (1850). Subsequent dock construction resembled that at Liverpool in that it extended along the extensive water fronts; but it differs somewhat in the methods adopted. For farther to the south-west the work was carried out by constructing a great embank-

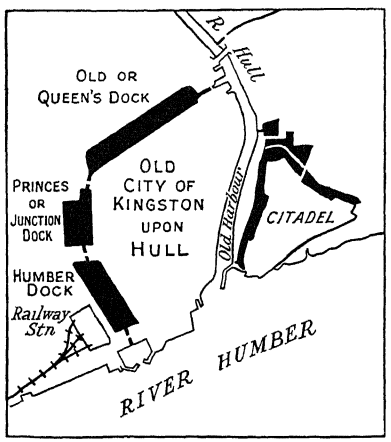


FIG. 285.—The port and docks of Hull in 1840

ment along the line of the estuary and thus producing behind it the St. Andrew's Dock (1883), the Albert Dock, and William Wright Dock (1869), these three being to the west of the town. Of necessity, later development had to be farther downstream, where there is the giant Alexandra Dock opened in 1886, and the King George V Dock opened in 1914. At first it is to be noticed that railway construction merely emphasised the existing lines of communication, and amongst the early disconnected portions of railway constructed, that from Hull to Selby, and the industrial West Riding, was both noteworthy and early.[1] Subsequent railway construction extensively widened the hinterland served by the port. It is interesting in this connection to notice that with the re-grouping of British railways in 1923, Hull became pre-eminently the port of the London and North Eastern Railway. The value of the export trade has never afforded

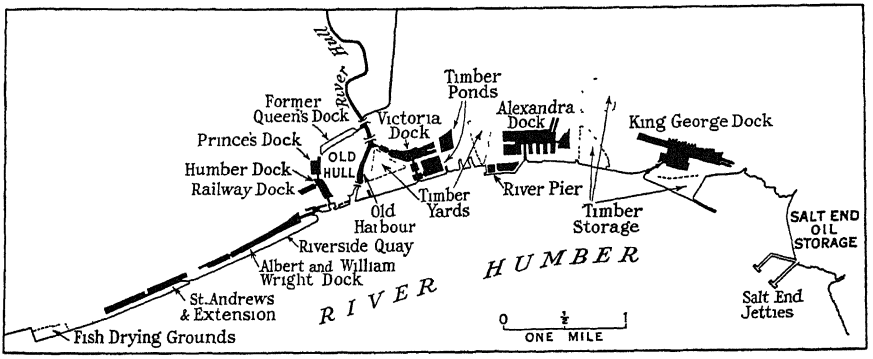


FIG. 286.—The port and docks of Hull at the outbreak of the Second World War. Queen's Dock had outlived its usefulness and had been filled in to form an open space

a very good index of Hull's importance because of the great bulk of coastwise traffic and the huge fish trade. Since the fish comes from British waters it does not figure as an import. The port resembles London in the very general nature of cargoes handled, and in that it is primarily an importing port, particularly of foodstuffs. Hull is the leading British port for the import of oilseeds. The seed is sent by lighters from the deep water docks to the crushing mills along the Hull itself and also to Selby. Similarly with wheat, of which there is a huge import; one finds flour-mills (with the seed-crushing mills) lining the banks of Hull for something like two miles. The concentration of flour milling at the great ports of the British Isles is a very marked feature and has been responsible for the decay of milling in many smaller towns. For example, some of the wheat imported at Hull was formerly sent for milling at York, but later the

[1] See Fig. 270.

York mills were closed. There is a large import trade in butter and bacon—obviously connected with Hull's suitability for distributing these commodities to the large industrial population of the north of England, and also obviously connected with the situation of Hull opposite the Continental ports, including those of Denmark, from which these commodities are exported. Similarly with the huge imports of timber—partly the result of the connection of the port with the great coalfields, and partly because Hull faces the European countries from which much of the timber is derived. As in many large ports refineries for mineral oil have been established —at Salt End. What is anomalous is that Hull is only third amongst the importers of wool, for it is obviously the port of the woollen region of West Riding. London is still the great wool market and most of the wool is imported into London. Although from here much of it goes by coastal steamer to Hull, it does not appear in the foreign trade of Hull (see p. 654). Hull occupies quite an important position in relation to the hidden eastern extension of the Yorkshire coalfield, and is likely to develop with that field. Something has already been said of the immense importance of Hull as a fishing port. The majority of Hull trawlers are big vessels, often absent for three weeks at a time, and therefore requiring large stocks of coal and ice, and really excellent facilities for handling the catch when they reach port. The St. Andrew's Docks are entirely given over to this traffic. Further, trawlers from Hull may land their catch direct in London at Billingsgate, or loosely packed in barrels in salt and ice at Belgian and other Continental ports. Hull had more than its share of bombing and the heart of the city was virtually eliminated. In plans for reconstruction land transport presented a major problem. The main docks are and must remain to the east of the city, the hinterland lies to the west. Railways crossed roads by a very large number of level crossings. Tunnelling is difficult because of a high water level in the alluvium: a succession of viaducts would be extremely expensive. The Humber cuts Hull off from direct communication with the south and a road–rail bridge has long been proposed.

GRIMSBY, INCLUDING IMMINGHAM AND GOOLE

It has been pointed out that the development of Hull as a port is closely bound up with its extensive hinterland and the waterways therein. It is clear that, provided deep-water facilities for ocean-going vessels are available, there must be other sites on or near the mouth of the Humber which could also handle the traffic of the same hinterland. There are now three ports which share with Hull the Humber trade—Grimsby, Immingham, and Goole. Grimsby lies to the south of the estuary of the Humber in the county

of Lincolnshire, 17 miles south-east of Hull. The potentialities of the site had long been apparent, but the development was left to the railways in the 'fifties of last century when the initiative of the Manchester, Sheffield, and Lincolnshire Railway, later part of the London and North Eastern system, began the transformation of a fishing village into a town of over 100,000 inhabitants. Grimsby is, of course, pre-eminently a fishing port, handling a quantity of fish which in inter-war years reached nearly a quarter of a million tons. There was a steady development of the fish traffic in the latter part of last century, but it was not until 1900 and the opening of No. 2 Fish

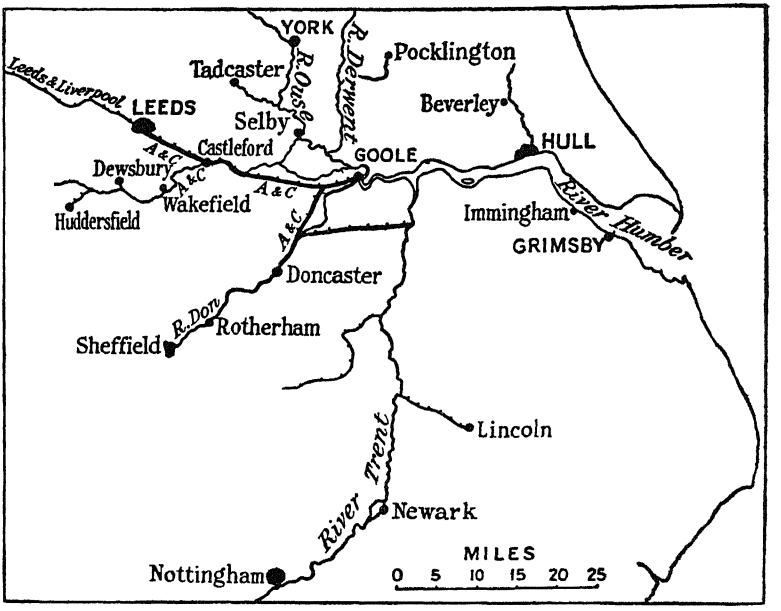


FIG. 287.—The Humber Ports

Showing water-connections with the hinterland, especially by the Aire and Calder Canal (A & C) All waterways marked are navigable (compare Fig 269)

Dock that an enormous extension of the fish trade took place, and now the fish expresses to all parts of Great Britain are a characteristic feature of the port. Of the foreign trade, timber is one of the most important commodities catered for at Grimsby. The Alexandra Dock in particular has huge floating space for timber and extensive storage yards. A large proportion of the import is of pitprops, and there is a corresponding export in the trade in coal. There is also an import of iron ore, and facilities exist at the port for the handling of pig-iron and wood pulp. But the entrance to the Grimsby Docks is through a tidal basin and the largest lock is only 70 feet wide. The main channel of the Humber does not swing

along the coast here and there is a huge stretch of mud at low tide. Five miles to the west of Grimsby, however, there is a position where the main channel of the Humber approaches the shore. Here Immingham Dock was constructed and opened in 1912. The entrance lock is 840 feet long, 90 feet wide, and has a depth on the sills at mean low-water spring tides of 28 feet. The port is specially concerned with the shipment of coal, and the import of pitprops and other timber. Grimsby and Immingham, both from 1923 to 1948 on the London and North Eastern Railway system, have an important rival in Goole which, though owned by the Aire and Calder canal with which it originated, is the corresponding port on the former London, Midland and Scottish system. Goole is directly connected with Leeds by the Aire and Calder canal system, and there are express chains of barges using this canal—now one of the most important inland waterways in the kingdom. Excellent facilities exist at Goole for coal shipment and for the import of timber, iron ore, and similar bulky commodities. It has some direct near-continental trade.

SOUTHAMPTON [1]

Southampton is the chief commercial port on the south coast. Although the Docks are of comparatively modern origin, dating from 1842, the port itself has played a long and notable part in the history of Britain. In A.D. 43 the Romans established a station on the east bank of the River Itchen; the Norman Conquest established it as the port for the royal city of Winchester, then capital of England, and by 1450 Southampton ranked as the third port of Britain.

Good geographical position and natural advantages have contributed to making Southampton a foremost port. Situated in the centre of the south coast, within easy reach of London and the Continental ports of Havre and Cherbourg, the Docks stand at the head of Southampton Water, a well sheltered estuary leading from the English Channel, with the Isle of Wight forming a natural breakwater at the entrance. The approaches to the Docks enjoy a great natural depth of water, in fact it was not until 1882 that dredging had to be resorted to for deepening, but with the advent of the big ocean liners, drawing up to 39 feet of water, dredging has, of course, been necessary, and today the main channel of Southampton Water is 800 feet wide with a minimum depth of 35 feet at low water.

Another natural advantage is the relatively small tidal range of only 13 feet, making closed docks unnecessary, but undoubtedly the greatest natural advantage which has aided Southampton is the phenomenon of a double high tide whereby the period of high water

[1] We are greatly indebted to Mr. R. P. Biddle, Docks and Marine manager, for the revision of this section.

is maintained for two hours twice during the twenty-four hours. In addition, there is the "young flood" stand, which is an interruption of the normal tidal rise causing a slack-water period occurring from $1\frac{1}{2}$ to 3 hours after low water; thus during the twenty-four hours of each day there are seven hours slack water at a level navigable by all types of ships. Various theories[1] have been advanced as to the cause of the double tides and the unusual feature of such a short ebb but no one theory completely accounts for all the features experienced in the port.

Unlike most other great commercial ports, the Port and Dock Authorities at Southampton are not a single entity, the Docks,

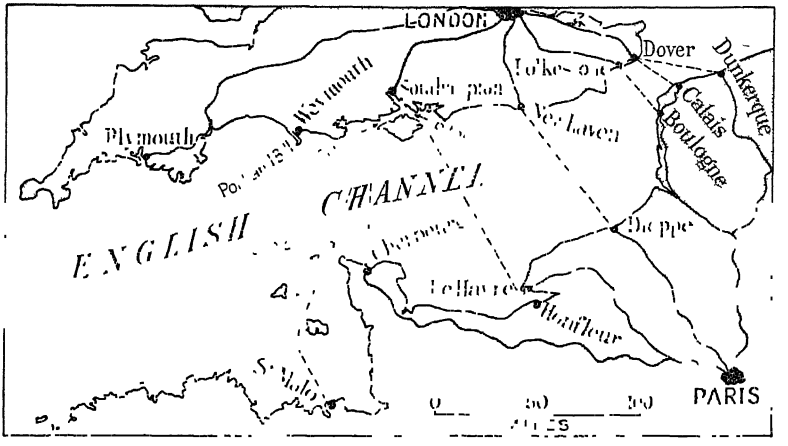


FIG. 288.—The position of the port of Southampton relative to the English Channel, showing the narrowing between Cape de la Hague and Portland Bill which is believed to cause the double tides of Southampton

The principal cross-channel routes between Britain and France are also shown. The former Southern Railway initiated a train-ferry service from Dover to Dunkerque in 1936 permitting through coaches from London to Paris

although within the port area, being administered by the Docks & Inland Waterways Executive of the British Transport Commission, whilst the Harbour Board, as the Port Authority, exercises jurisdiction over the approaches to the Docks and is responsible for dredging, buoyage and other conservancy matters within the port area.

The modern system of docks at Southampton was not started till 1838, when a small group of business men, realising the potentialities of Southampton as a port, founded the Southampton Dock Company, and the first dock was opened for trade in 1842. The first engineer of the Dock Company was Francis Giles (succeeded

[1] F. W. H. Green, "Tidal Phenomena, with special reference to Southampton and Poole," *Dock and Harbour Authority*, Sept., 1951.

later by his son Alfred Giles), who from the start laid out well-equipped quays in such a way that passengers and cargo could be brought from and sent to London and other inland destinations with the maximum of speed. In 1892 the Docks were transferred from the Southampton Dock Company to the London & South Western Railway (later the Southern Railway) and in 1948 passed to the British Transport Commission, being subsequently placed under the control of the Docks and Inland Waterways Executive.

Some measure of the prosperity the Docks have brought to Southampton is shown in the growth of population of the town, from 65,621 in 1892 to 180,000 in 1953.

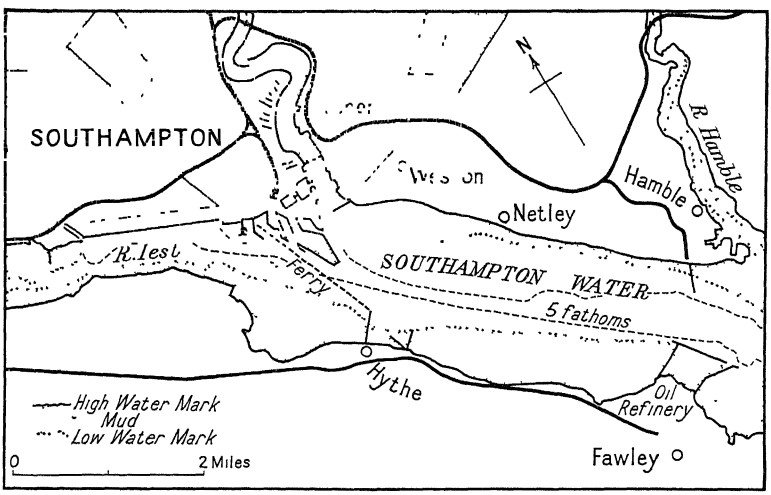


FIG. 289.—The port of Southampton

Showing the extension westwards made between the wars with the largest graving dock in the world—capable of taking larger vessels than any built, when the dock was opened in 1933

The Old Docks, covering some 200 acres, form a triangle with the apex at the confluence of the Rivers Itchen and Test. In addition to the river quays there are three large tidal basins, the Ocean Dock, Empress Dock, and Outer Dock. The Ocean Dock is the main base of the North Atlantic express passenger services, and the Ocean Terminal, a double-storey passenger and cargo reception station on the eastern side of this dock, completed in 1950, after severe war-time bombing and destruction of older installations, is acknowledged to be one of the best of its kind in the world.

To the north-west of the Old Docks, facing the River Test, are the New Docks, begun in 1926 and completed in 1934 by reclaiming a bay of 400 acres of tidal mudland, giving a straight line of 1½ miles of deep water quay, with adjacent passenger and cargo sheds, railway

sidings and every appliance for the rapid handling of passengers and freight. At the western end of the New Docks is the King George V. dry dock, which can accommodate the largest vessels afloat—including the *Queen Elizabeth* (80,000 tons) and *Queen Mary* (79,000 tons), which regularly use the port. Immediately behind the New Docks quays are 130 acres of reclaimed land which is gradually being developed as an industrial estate.

Southampton is Britain's premier passenger port, dealing with over fifty per cent. of all ocean-going passengers to and from the

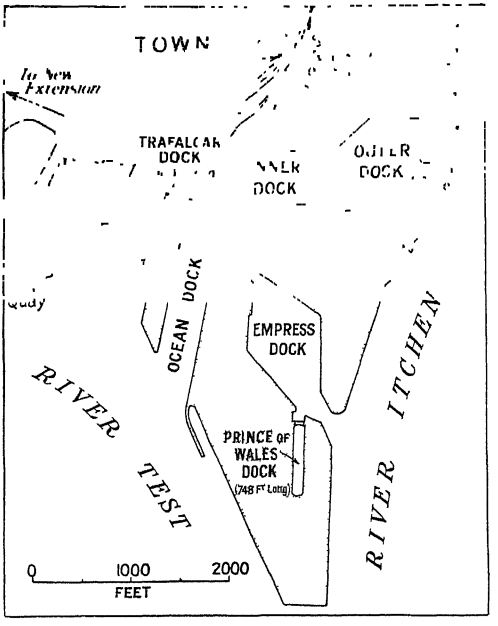


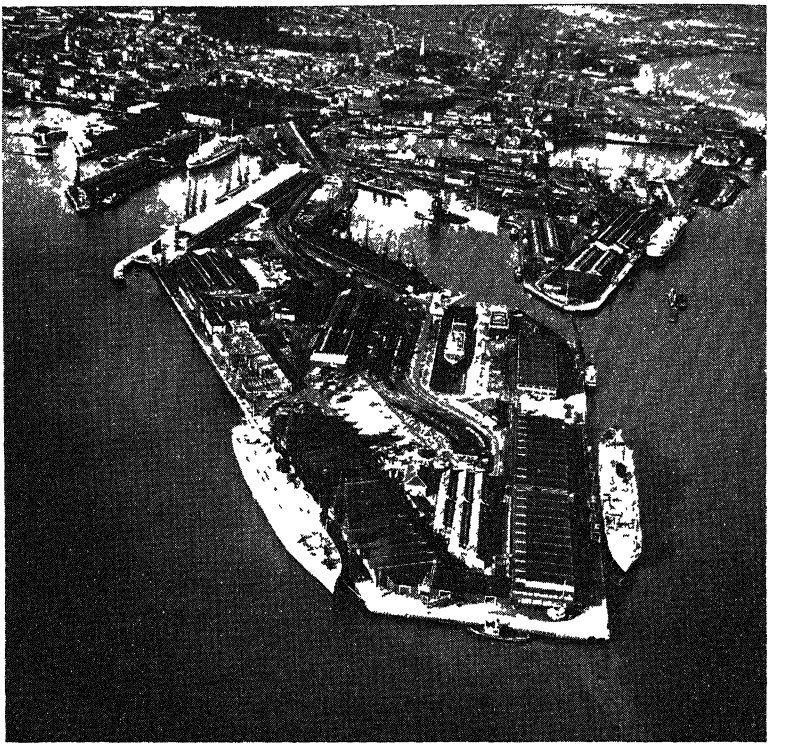
FIG. 290.—Details of the older docks of Southampton

Owing to the small tidal range and sheltered position there is only one small non-tidal dock (the Inner Dock)

United Kingdom; seventy-six per cent. of those to and from the United States and seventy-two per cent. of those to and from South Africa. Thirty of the world's principal shipping companies maintain regular passenger services from Southampton to all parts of the world, and from the inception of the Docks in 1842 Southampton has always dealt with the world's largest liners. In this connection it is interesting to note the situation of Southampton relative to the position of Britain described in Chapter I. It will be seen that steamship services from the northern coasts of Europe, for example, Germany and Holland, proceeding to the Americas or elsewhere are not taken out of their way to any appreciable degree in order to call

at Southampton. Hence it is or was the regular calling place of the German liners of the Hamburg-Amerika and Norddeutscher Lloyd.[1]

Southampton also ranks as one of Britain's principal cargo ports. Practically the whole of the South African deciduous fruit shipped to Britain is received at the Docks as well as about three-quarters of



Aerofilms Library, London

FIG. 291.—Air view of the Old Docks, Southampton

the citrus fruit. Wool, hides, skins, wines, canned fruit, and jams are also received from South Africa. Other imports at Southampton are bananas from the West Indies and West Africa, fresh fruit and vegetables from the Channel Islands and France, timber from the Baltic and Central Europe, grain from Australia, Canada and South America, as well as from English ports, and also coastal cargoes from Scotland and Ireland. Exports include motor cars and practically

[1] Until 1933 some dropped anchor in Cowes roads, without proceeding up Southampton Water. This accounts for the huge tonnage of shipping credited to the "port" of Cowes in the years 1930–1932, and is a warning to the careless reading of port statistics. Dutch liners (Holland-America) still call in this way.

every variety of manufactured British goods, shipped to all parts of the world. Southampton's geographical position has made it a good centre for the reception and distribution of cargo of all kinds, especially perishable and express goods. Within a hundred miles radius there is a population of 16,000,000, an area embracing London (which is reached in under two hours by passenger train and in three hours by freight train), the industrial midlands, etc., all linked to Southampton by regular rail and road services giving rapid and economic transport and distribution.

Although the bulk of the general cargo traffic is dealt with at the Docks, about one million tons of cargo is handled annually at the Town Quay, which is owned by the Harbour Board. At the Esso Oil Refinery at Fawley, on the west bank of Southampton Water (completed in 1952, and the largest oil refinery in Europe) nearly 20,000 tons of crude oil are received daily at the 3,200 ft. long jetty, where four tankers can be dealt with simultaneously.

Southampton was the first port in the United Kingdom to become a licensed commercial aerodrome and flying-boat services are operated between the Docks and Madeira.

For the dry docking and repair of ships there are seven dry docks, ranging in length from 281 to 1,200 feet, and overhauls of the largest liners in the world are carried out at the Docks. John I. Thornycroft's shipbuilding yard at Woolston, on the eastern bank of the River Itchen, is noted for the building of naval and commercial vessels.

HARWICH, DOVER, FOLKESTONE, AND NEWHAVEN

It is from these ports that the passenger-ferry services to the Continent leave Britain, and to which the now obsolescent term "packet station" was formerly applied. Harwich serves Holland (the Hook and Flushing) and Denmark (Esbjerg); Dover serves France (Calais and Dunkerque) and Belgium (Ostend); Folkestone serves France (Boulogne), and Newhaven, France (Dieppe), apart from passengers they all have a trade somewhat similar in character and function broadly comparable in each case. They all have an import trade made up of perishable articles such as butter, eggs, fresh meat, poultry, fish, and fruit, as well as manufactured goods of relatively high value in proportion to their bulk—*e.g.* fine silks and wearing apparel of Parisian origin. On the other hand, they have a very small, often negligible, export trade.

BRISTOL

Bristol is an excellent example of a port which had initial geographical advantages of which it made full use, but whose advantages were not of the character that could be so readily adapted

to supply modern requirements as was the case, for example, with London and Liverpool. Thus Bristol, though remaining a port of no mean significance, has failed to remain in the first rank. There is no evidence of a Roman settlement at Bristol, but the low sandstone hill naturally protected by the marshes of the River Frome on the north and the marshes of the River Avon on the south, the two rivers joining farther to the south-west, supplied an excellent defensible position in the troublous times of Saxon England. Below Bristol the River Avon passes through its famous limestone gorge and empties into the lower part of the estuary of the Severn. The shallow and tortuous course of the upper part of the estuary of the Severn gave Bristol an advantage in competing as an outlet not only for the region to the east of it, but also for the Severn valley.[1] The route eastwards from Bristol was well known because of the Roman spa at Bath which was popular at an early date. Connections with Ireland date from an early period and almost equally fundamental relations with France and Spain are indicated by the early development of the wine trade, wine being an important item in the imports of Bristol then as it is to-day. Soap-making, tanning, and wool weaving developed in the thirteenth century, and in 1353 Bristol was made one of the staple towns for the export of wool. The growing importance of the centre was recognised in 1373 when Edward III granted a charter whereby the town and suburbs of Bristol were made into a separate county. In the meantime the settlement had spread to other sandstone hills in the neighbourhood, and the low ground was utilised for the construction of quays. The discovery of America [2] opened a new field for Bristol; but at first there was severe competition between the port and London. The Merchant Adventurers Society of Bristol received its charter in 1552, but London shot ahead and monopolised much of the new trade. However, the foundation of colonies in Virginia in 1606, and Newfoundland in 1610, saw many men from the west country taking part. The famous Hakluyt himself was Dean of the cathedral from 1586 onwards. So in the early part of the seventeenth century came the development of the American trade. Though a decree of 1631 had enacted that tobacco should only be imported into London, there was so much smuggling into Bristol that its importation was legalised in 1649. Then came the development of the great Trade Triangle from Bristol just as from Liverpool; Bristol vessels going to West Africa, taking a cargo of slaves to the West Indies and returning to Bristol. As early as 1612 there were evidently sugar houses in Bristol because there was a

[1] Despite the construction of the Berkeley Canal, allowing the passage of vessels of 11 feet draught, Gloucester fell behind in the competitive race.

[2] It was John Cabot, a naturalised Venetian of Genoese birth, who had settled in Bristol as a merchant, who really discovered the North American Continent by landing on Cape Breton Island in 1496

protest demanding the removal of one such owing to the danger of fire. The first mention of the establishment of the chocolate industry is in the granting of a patent in 1731 to Walter Churchman of Bristol, whilst in 1753 Joseph Fry was admitted as a freeman of Bristol after five years' residence. But the tortuous course of the Avon practically prohibited the ascent of vessels exceeding 150 tons, and the Merchant Adventurers were compelled in the early part of the eighteenth century to spend considerable sums on additional moorings and the removal of rocks. There was much discussion about the construction of new docks, but nothing definite was done. Bristol largely lost the sugar trade which it has never

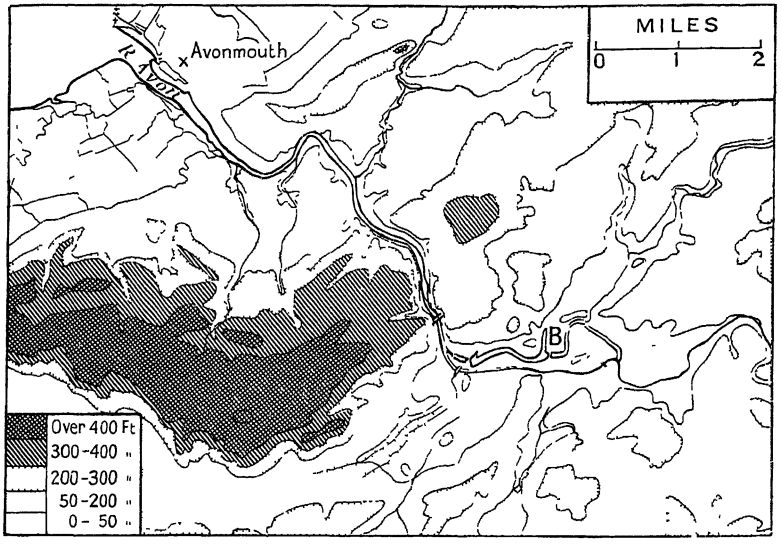


FIG. 292.—The physical setting of the city and port of Bristol (B)

Note the ridge of high ground through which the River Avon cuts in the famous Avon gorge *between* Bristol and the sea. This has effectually prevented Bristol from becoming a modern deep-water port, hence the growth of the outport Avonmouth

quite recovered. By the time the docks were constructed in the early part of the nineteenth century, it was too late and prohibitive dues annulled the advantages of the new docks. With the coming of the railway era Bristol was unfortunate in its close relationship with the network of 7-foot gauge lines of the old Great Western Railway. These held back the trade of the city especially in connection with the trade of the Midlands; the change of gauge rendered necessary the handling of goods at Gloucester, putting up transport costs and resulting in the diversion of the traffic to Liverpool. It might be thought that the situation of Bristol so close to the Bristol coalfield would have been a tremendous advantage; but there was never any measure of agreement between the coal-owners and

workers and the city authorities in Bristol. Indeed, in 1727, a bill was passed which permitted the setting up of toll gates and taxation on every ton of coal entering Bristol for consumption. But Bristol occupies an essentially valuable position in the west of England, and the obvious though bold move was the construction of modern deep-water docks at the mouth of the Avon. This was undertaken both to the north of the Avon at Avonmouth and to the south at Portishead, but whilst Avonmouth went ahead, Portishead became almost disused, except for coal to supply the power station. One disadvantage of Avonmouth is the enormous rise and fall of the tide, so that vessels have to wait for high tide before they can leave the docks. But facilities have been provided particularly for petroleum storage, the cold storage of butter and meat, the handling, storage, and milling of grain, and a special feature of Avonmouth is the docking there of the West Indian banana vessels. Thus the import trade of Bristol has again shown a marked tendency to increase; but the exports are small. The manufactures of the city remain those connected with its old West Indian trade—tobacco, chocolate, and soap in particular.

GLASGOW

The city of Glasgow is situated on the River Clyde 22 miles from the sea. The port is in reality the result of efforts made by the citizens of Glasgow to overcome geographical disadvantages. Less than 200 years ago the River Clyde below Glasgow was a spreading and shallow stream full of shoals and sandbanks, fordable at many points as far down the river as 12 miles from Glasgow Bridge. Only about a hundred years ago the river was only navigable by small craft drawing not more than six or seven feet of water. As early as 1668 the town council decided to construct their own port by buying a piece of land 13 acres in extent at a point 18 miles down the river on its left bank. The construction of the town and harbour at New Port was undertaken, the name being changed subsequently to Port Glasgow. Here, in 1812, was built the first dry dock in Scotland. But Port Glasgow was too far away, and already towards the latter part of the eighteenth century efforts had been made to confine the water to the centre of the channel and so to increase the effect of scouring. In 1824 the first steam dredger was brought into operation, and since that date there has been a systematic improvement of the river carried on almost continuously by dredging —as well as the cutting away of the Elderslie rock which presented a serious obstacle for many years. Thus there is now a channel of about 26 feet in depth at low water which, added to a tidal rise of 11 to 12 feet, makes the port accessible for steamers of the largest trading class. Docks have been constructed and the port is now

well equipped. The expenditure on the improvement of the River Clyde below Glasgow was warranted by the development of the hinterland. The occurrence of coal and iron close together in the immediate vicinity of Glasgow converted it into the centre of a great manufacturing region. The fact that the bed of the river below Glasgow was filled by easily dredged material and mostly soft rocks rendered possible also that extension in width which has enabled the great shipbuilding yards along the Clyde to continue in operation as the size of vessels built there has increased. Then there is, further, the fact that Glasgow shares with Liverpool the advantage of facing the New World. It is true that the North American and West Indian trade began as a smuggling trade before the union of the English and Scottish Parliaments, but after the Act of Union so flourished that Glasgow led all its English rivals in the tobacco trade. However, Glasgow, unlike most of the ports of Britain, has developed an exporting trade more than an importing trade. The imports, especially foodstuffs, which are required by Scotland enter the country particularly by the eastern ports of Leith and Grangemouth, the latter having supplanted Borrowstounness, or Bo'ness, to a considerable degree. Of the future it is difficult to speak, and it has long been realised that Glasgow would benefit considerably by the construction of a ship canal across the narrow waist of Scotland where vessels could coal cheaply en route, and it is quite conceivable that this line would be followed by great trans-Atlantic steamers from the northern coasts of the Continent of Europe on their way to North America. But costs of construction are prohibitive.

LEITH AND GRANTON

Edinburgh has the advantage of two seaports within its extended boundaries—Leith and Granton. Leith has an import trade similar in many respects to that of Hull, and thus serving as an inlet for butter, sugar, cheese, eggs, and other continental produce required not only for the Edinburgh district, but for the more populous district of the Lanarkshire coalfield farther west. Granton has not the same facilities for distribution, and specialises rather for ships laden wholly with one bulky commodity. Similarly Grangemouth and Bo'ness specialise particularly in the importation of timber and pitprops required for the collieries and iron ore from Sweden.

THE TYNE PORTS

The River Tyne from Newcastle and Gateshead to the North Sea forms what is really one large sheltered port. The river valley is entrenched in the low plateau of the coalfield, but the rocky floor of

the valley lies well below sea level and has been partly infilled with glacial drift. This drift can be excavated with relative ease and this has permitted a dredging and deepening of the river channel to keep pace with the increasing size of vessels launched from Tyneside shipyards. As a port Tyneside has been proverbially (coals and Newcastle) associated with the export of coal for at least six centuries (see above, Chapter XIV) and formerly the value of exports exceeded imports. By contrast with the huge excess of imports over exports characteristic of London, the excess is still small in the Tyne ports. The several bridges connecting Newcastle and Gateshead are the lowest on the river and are about ten miles from the mouth. Colliers ascend higher, passing under the high-level bridges and by the help of swing spans through the low level. The river mouth with Tynemouth to the north and South Shields to the south is sheltered from North Sea storms by extensive stone piers or breakwaters. As a passenger port, Tyneside provides the short sea route to Scandinavia via Bergen. As an industrial port many industries besides shipbuilding have been established along the river, some to persist, others to rise, flourish, decay, and die so that considerable industrial sites are available for re-use.

North of the mouth of the Tyne, the coal port of Blyth stands at the mouth of the river of the same name. A few miles south of the Tyne, the River Wear reaches the sea. Because the Wear has a rocky bed, in contrast to the Tyne, shipbuilding has been restricted to the area near the river mouth where Sunderland has grown up and the vessels launched are all of small draught.

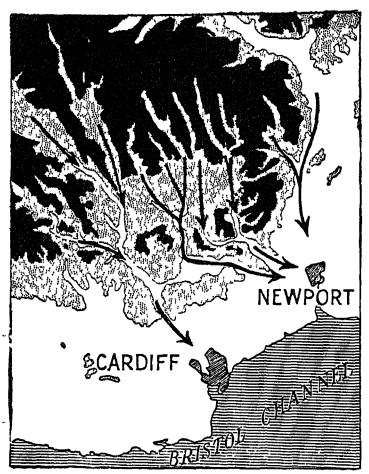


FIG. 293.—Sketch map showing the position of Cardiff and Newport relative to the coal-mining valleys of the South Wales coalfield

Land over 500 feet dotted, over 1,000 feet black

THE SOUTH WALES PORTS

For long the prosperity of South Wales depended in large measure on the export of coal—especially the hard steam coals used for bunkering of steamers and the maintenance of supplies in overseas coaling stations. From the narrow mining valleys to the coast is downhill, so that gravity aided the movement of coal by rail whilst the fusion of a number of valleys in each case into the Taff and Usk led naturally to the development

respectively of Cardiff and Newport at their mouths. Towards the western end of the coalfield, valleys converged in somewhat similar manner on Swansea. Cardiff and Newport were accordingly equipped with large-scale machinery for the handling of coal; Swansea was concerned also with the import of iron ore, copper, and nickel matte for its smelting works. Amongst other ports which grew up may be noted Barry, Penarth, Port Talbot, and Llanelly. Reference has been made elsewhere to the vicissitudes of the iron and steel industry in South Wales. An important advance was marked by the decision, reached before the end of the Second World War, to build a large modern steel rolling mills on coastal flats just south of Port Talbot.

MINOR PORTS

Nothing has been said in this Chapter of the many small but interesting ports which still play a significant part in the life of the British Isles. The numerous fishing ports of present and past have been considered in Chapter XIII and many of the old fishing ports have a new function in that they cater for pleasure boating and sailing for summer visitors. Then quite a considerable number of ports are significant to-day for coasting trade, especially for heavy and bulky commodities of which coal is the outstanding example. There is a coastwise despatch of coal from such ports as Burntisland and Methil in Fifeshire, or Whitehaven in Cumberland, and quite large quantities are received at such centres as Ipswich and Shoreham.

Some ports exist to handle the shipment of a local product—one thinks of Fowey, Par, and Charlestown despatching the china clay of Cornwall, whence it goes to the Potteries or even to America. Building stones such as the granite of Peterhead or road metal are advantageously handled by direct water transport. Many manufacturing centres have their own port facilities—such as Middlesbrough for receipt of iron ore and despatch of iron and steel, the cement ports of the Thames and Medway, where the wharves are normally owned by the industrial concerns and do not handle commodities other than their own.

Dockyards and naval ports such as Rosyth, Chatham, Portsmouth, and Devonport (Plymouth) form another group. Still another class are those ports serving Ireland or outlying parts of the British Isles: Stranraer, Larne, Heysham, Holyhead, Fishguard, Penzance, Weymouth, Wick, Thurso, Stornoway, and Oban are a few examples which spring to mind. Fishing ports are considered in Chapter XIII.

Despite the decadence and demise of some, the general impression is one of the extreme richness of the British Isles in natural inlets and harbours which continue to serve so well as ports.

THE HINTERLANDS OF THE PORTS OF BRITAIN

It is not possible to delimit with accuracy the hinterlands of the ports of Britain. Several points may be emphasised. The first is the great extent to which the hinterlands overlap. Thus London serves an ever-increasing area, including not only the greater part of the Midlands of England, but much of the industrial north. Obviously Liverpool embraces within its hinterland the whole of the Lancashire and the Yorkshire industrial regions as well as the industrial regions of the Midlands of England. Hull, whose hinterland was in general co-extensive with the Ouse-Trent Basin, now for some purposes extends its tentacles farther, *e.g.* to east Lancashire. But a factor which it is essential to remember is the specialisation of the modern port for the handling of certain classes of goods. Just to take one small example, Avonmouth has been specially equipped to handle the bananas which are imported in huge quantities into this country. It is true that in this traffic it has rivals in Garston and London, but notwithstanding that bananas are delivered by rail to all parts of Britain from Avonmouth. In this sense, therefore, the whole of Britain may be regarded as lying in the hinterland of Avonmouth. It is only, therefore, in the broadest possible sense that one can attempt any sort of delimitation of British hinterlands.

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CHAPTER XXIX

THE IRISH REPUBLIC[1]

Introductory

In the earlier chapters of this book the British Isles have been considered as a whole. It is impossible in any general study of the geology, geographical evolution or climate of the British region to ignore either the whole or part of the island of Ireland. When, however, one comes to consider the various aspects of economic geography which have been taken up in turn the emphasis has been on the main island of Great Britain or on the political unit of the United Kingdom of Great Britain and Northern Ireland.

In the earlier editions of this book separate chapters were devoted to the agricultural regions, the industrial regions and the ports of Ireland and there were extended references to Ireland in many other chapters. This was for two reasons. In the first place the separation of the Irish Republic as a political unit was then comparatively recent, many of the statistics then available referred either to the whole of Ireland or to the whole British Isles. In the second place Ireland had been much neglected by geographers and my own work in the country in preparing my *Agricultural Atlas of Ireland* (1931) had convinced me of the great importance of instituting comparisons and contrasts between Ireland and Britain.

The position has now completely changed. The Irish Republic has been in existence as an independent country since 1921 and a body of statistical material has been built up over the intervening years. In the second place many geographical studies have been carried out in Ireland: in particular there is an excellent and comprehensive account in T. W. Freeman's *Ireland*, first published in 1950. For details and references on all aspects of Irish geography recourse should be had to Freeman's work.

The present chapter has been included for the sake of completeness, but it should not be regarded as more than the merest introduction to the geography of a very interesting country.

Historical Note

The Irish Republic is a sovereign independent state and its jurisdiction covers 26 of the 32 counties of Ireland including the whole of the three historic provinces of Leinster, Munster, and Connaught

[1] We are deeply grateful to Mr. T. W. Freeman for most valuable comments on this chapter and the next.

(Connacht), together with three of the counties (Cavan, Monaghan, and Donegal), of the former province of Ulster.

After what has since become known as the Easter Rebellion of 1916 a Republic was proclaimed and in due course the British parliament recognised its independence. On 6th December, 1921, the Treaty was signed and a boundary was demarcated between the Irish Republic and Northern Ireland. From 1921 to 1937 the official-name used for the Republic was Saorstat Éireann, or the

FIG. 294.—Political map of Ireland

Irish Free State. Later the name Eire (literally Ireland, since the State does not officially recognise the existence of Northern Ireland) came to be used, to be changed in due course to the present official title, the Irish Republic, or Poblacht na h Éireann.

Apart from the fact that there are close commercial ties between the Irish Republic and the United Kingdom in that the large population of Britain forms a natural market for Irish agricultural produce, the Republic is independent in every way of the United Kingdom Government and ceased to be a member of the British

Commonwealth in 1949. The head of the Irish Republic is the President, and government is by the Dail and Senate.

Population

The total area of the Irish Republic, excluding the larger rivers, lakes and tideways, is officially given at 17,024,116 acres. The population at the census of 1951 was 2,960,593, of whom over 94 per cent. are Roman Catholics—with the percentage increasing.

The population of the island of Ireland expanded rapidly from about 1770 to the eighteen forties. This expansion was made possible by the great development in the cultivation of potatoes, which became the staple article of diet of the Irish farmer and farm worker. The failure of successive potato harvests led to the terrible famines of the years 1845–1847, in the course of which very large numbers died of starvation, and which gave rise to the great streams of migrants, especially to the United States. Ireland has in fact never recovered from the effects of those famines of over 100 years ago, and in the past century the total population has been reduced by half.

The first actual census of the whole island was taken in 1821 and recorded a population of 6,802,000. This total by 1841 had reached 8,175,000 and by 1845, when the famine struck, was probably approaching 8½ million despite the considerable emigration which had already taken place. This may be contrasted with the population of the Irish Republic and Northern Ireland in 1946 of 4,289,000. It will be noted that the population of Northern Ireland is now steadily increasing and this may be connected with the industrialisation of Belfast and neighbourhood. In the Irish Republic, on the other hand, the population continued to decline slowly, though much less rapidly than formerly, until the slight increase shown in 1946–1951.

In contrast to the present population in the Irish Republic of less than three million the number of emigrants has been truly remarkable. There was no count of the immigrants at the ports of entry before 1851, but it was calculated that there were already nearly one million in the United States, three-quarters of a million in Britain, and one-quarter of a million in Canada. In the year 1847 alone more than a quarter of a million Irish refugees landed at Liverpool, the majority of whom settled in the growing factory towns of the north of England, where their descendants remain to this day.

In the ten years 1851–1861 another 1¼ million emigrants left the ports of the British Isles, mostly destined for the United States and Canada. So migration went on and although it steadily slowed down, especially after 1891, over two million have left the island in the past fifty years. Since 1930 the main migration from Ireland has been to Great Britain. It is of course difficult to give

anything approaching exact figures, but it has been estimated that people of Irish descent living in America and elsewhere total something like 16 million or more than five times the total number remaining in the Irish Republic.

Considerable parts of Ireland are actually uninhabited: the mountains and the lowland bogs, so that if one excludes these uninhabited areas the population density over the settled parts presents a very different appearance from population density calculated over the whole. At the census of 1946 average rural density in the whole Republic was 70 per square mile, but excluding the uninhabited areas about half the country had an average density of between 50 and 100, much of the remaining half between 100 and 200 whilst the inhabited fringes of the remote west, the so-called congested districts, supported between 200 and 400 persons per square mile, in some cases actually over 400 per square mile of cultivated land.

Over the greater part of the Irish Republic the rural population exceeds 75 per cent. of the whole. The settlement is scattered, villages are rare. Although the word "town" is used to cover nucleated settlements, many of the so-called towns boast less than 200 people and indeed many places with between 800 and 1,500 people are, in social and economic functions, towns. The needs of farmers are served especially, however, by those market towns which have between 1,500 and 5,000 people. There are rather over 70 of this size in the Irish Republic, and a much smaller number of larger ones. In the Irish Republic Dublin with its port, Dun Laoghaire, boasts over 600,000 people, and stands in a class by itself. The expansion has been particularly marked since 1946. If one includes the surrounding residential areas Cork exceeds 100,000, Limerick has now over 50,000 and Waterford has about 28,000. These four towns, however, have exhibited the phenomenon of urbanisation which is almost universal. Over the period 1891–1946 the four together had increased by 43 per cent. and at the census, 1946, contained more than one-quarter of the total population. By way of contrast the purely rural areas, including settlements of less than 1,500, had decreased by 29 per cent. over the same period and from embracing three-quarters of the total now have only a little over 60 per cent.

It will be clear that apart from the four towns specially mentioned the Republic remains essentially rural and agricultural

Agricultural Regions

The agricultural regions of Ireland show a close coincidence with those determined on a basis of geological structure and relief, although the old familiar statement that Ireland consists of a central plain—more strictly a low plateau so plastered with glacial deposits

as to have everywhere impeded and irregular drainage—with an interrupted rim of mountains and hills remains broadly true.

One must remember, however, that the rim is very irregular in character and consists really of a number of isolated hill masses, whilst the central plain itself is interrupted especially towards the southern western margins by numerous ranges or isolated hill masses. The central plain further reaches the coast in a number of points.

The physical regions which may also be discussed as agricultural regions are shown on Fig. 295. This may be compared with the

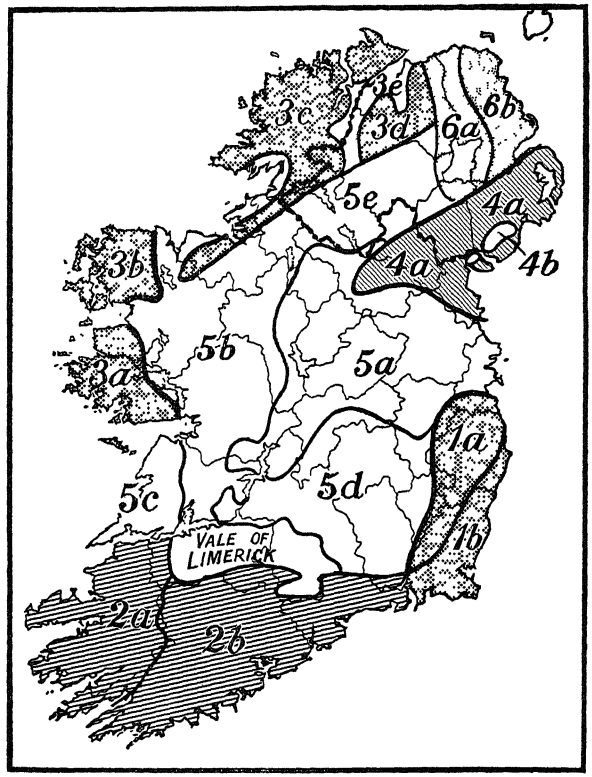

FIG. 295.—The Agricultural Regions of Ireland
For explanation, see text

next figure, simplified from a map prepared by Mr. T. W. Freeman, showing the types of farming in Ireland.

The regions may now be taken in order.

(1) The mountains and uplands of the south-east (Wicklow and Wexford).

(2) The parallel ranges and valleys of the south-west.

(3) The mountain masses of the north-west (Connemara, Mayo, and Donegal).

(4) The uplands of the north-east which are a continuation of the uplands of Northern Ireland.

(5) The Central Plain and its fringing areas.

A comparison of Figs. 295 and 296 suggests a quite remarkable correlation between physical regions and types of farming.

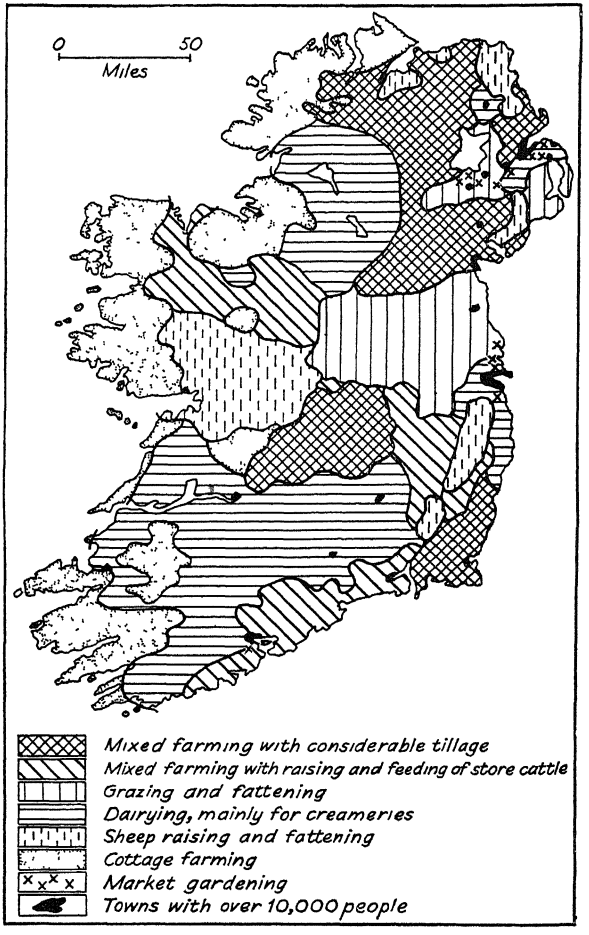

FIG. 296.—Types of Farming in Ireland

(Simplified from T. W Freeman, Ireland, by permission of the author and Messrs. Methuen & Co. Ltd.)

(1) The Mountains and Uplands of the South-East or the Leinster Chain

This well-marked area was doubtless once continuous with North and Central Wales, with which the south-eastern part in particular

is structurally similar; the northern part (actually forming the Wicklow Mountains) consists in the main of the largest granitic intrusion in the British Isles. There is thus geographically a twofold division of the whole area:

(*a*) The *Wicklow Mountains*, which narrow southwards on the other side of the gorge of the river Slaney to Mt. Leinster and the Blackstairs Mountains.

(*b*) The *low plateau* or *uplands of County Wexford*, which extend northwards, narrowing to form the coastal belt of the eastern part of Wicklow.

The whole region is remarkable in the first instance because of the completeness of the barrier which it offers between the south-eastern coast of Ireland and the central lowlands. The whole region may, alternatively, be called the Leinster Chain, and to this day no railway crosses this barrier. Further, the main mass of the Wicklow Mountains is uncrossed even now by a motor road. The area may now be considered in its two parts.

The *Wicklow Mountains*, reaching northwards almost to the outskirts of Dublin, are remarkable not only for the barrier which they offer, but also for the contrast between the wide open moorlands of the higher parts, and the deep secluded valleys of the east. The moorlands reach elevations of over 3,030 feet in Lugnaquillia, the highest summit in eastern Ireland, whilst a very large number of the rounded summits of the moorlands reach over 2,000 feet. The breadth of the Wicklow Highlands varies between 10 and 15 miles. The streams which rise in the moors flow in comparatively broad shallow valleys until they reach the areas of slope which flank the chain itself. Here the descent is continued in deep gorge-like valleys which are frequently richly wooded, and these glens have long been famous for their scenic beauties, well-known examples being the Glendalough valley and the Avoca Vale. It is towards the south that the granite ridge is breached by the Rivey Slaney which passes through a deep gorge guarded by the village or small town of Clonegall. To the south-west of the Slaney gorge the Mt. Leinster-Blackstairs range has two nuclei each over 2,400 feet in height separated by the Scullogue Gap, a defile which has been used in the past by bold chieftains desiring to travel from Enniscorthy, the tidal head of navigation on the River Slaney, to Kilkenny, the next important centre towards the heart of the country. Because of their elevation the Wicklow Mountains experience a heavy annual rainfall, in spite of their situation on the eastern or drier side of Ireland. But in the secluded glens of the east the rainfall is less, and these glens benefit from the high summer temperatures, the July mean being over 60° F., although it is of course lower than in the corresponding regions in eastern England. These eastern glens,

being sheltered from the rainy westerly or south-westerly winds, form one of the few areas in Ireland where considerable extents of woodland have been preserved. Wicklow timber was valued in very early times and a process of systematic deforestation began when the Anglo-Normans of the Pale exported the oak and other woods in large quantities. The suitability of the area for afforestation has been recognised in recent years, and considerable areas have been

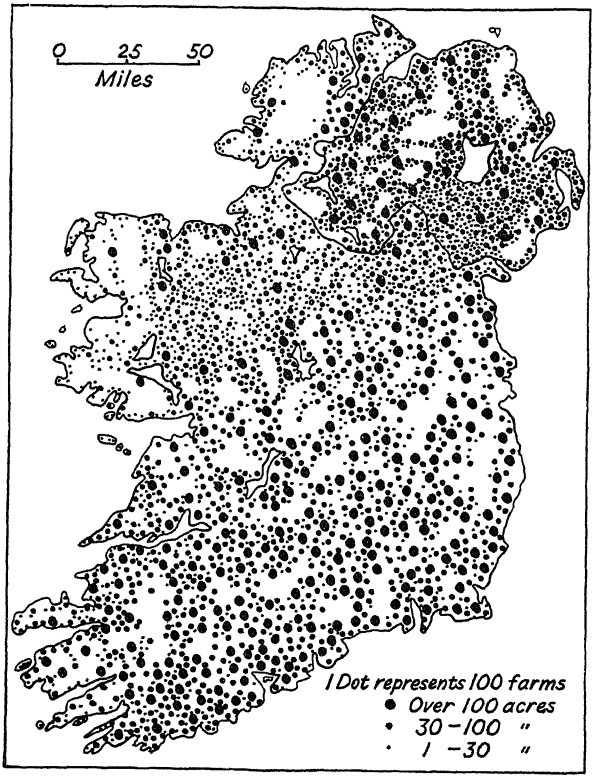

FIG. 297.—The Distribution of Farms of different sizes in Ireland

(From T. W. Freeman, Ireland, by permission of the author and Messrs. Methuen & Co. Ltd.)

planted. Agriculturally, the main importance of the area is for the sheep pastures which are afforded by the open moorland, but there are restricted though good areas of cultivation in the secluded vales. Thus the sheep farming of the centre gives place to rearing of store cattle on the margin, or to dairy-farming where accessible from Dublin and Bray. For long the tribes of the Leinster Chain maintained a sturdy independence. They had their strongholds at the entrances to the narrow valleys which led to the high moorlands, and to which

they could retreat if need should arise. Yet from the Bronze Age onwards the mineral wealth of Wicklow caused traders to be attracted to the district, particularly for gold and copper, ores of which occurred on the eastern side of the Highlands, and which became known to the people of all Ireland.

The *Wexford Uplands and Plains.*—To the south and east of the Wicklow Mountains there lies an area almost completely cut off from the remainder of Ireland. It occupies the greater part of Wexford and narrows northwards to form a small plain between the Wicklow Mountains and the sea. It is an area of old rocks which weather to form a moderately good soil. Over large areas glacial deposits are absent. Where they occur they consist mainly of shallow sands, marls, and clays which help to produce soil of excellent quality. As elsewhere in Ireland mixed farming is the rule: here more crops than usual. This corner of Ireland has relatively dry warm summers, and the climatic conditions combined with the soil have produced here what is *par excellence* the barley-wheat-oats region of the country, in which potatoes and pigs are also important. The country is undulating, and generally well drained so that bogs are almost non-existent. Although naturally not nearly so predominantly arable as the eastern parts of England, nearly a third of Wexford is recorded in the returns as arable. Despite this agriculturally favourable aspect of the country its isolation by nature is apparent from the numerous primitive little whitewashed cabins which are so reminiscent of the remote west. Northwards, where the plain narrows to the strip between the Wicklow Mountains and the Wicklow coast, is an interesting area sometimes referred to as the "Garden of Ireland." It is pleasant, comparatively well-wooded "close" country of very English aspect, free from bogs, and supporting numbers of dairy cattle as well as sheep. It is from this area that the valleys penetrate into the mountains. It might be thought that this pleasant coastland would have been subject to invasions from the east, that is, from the other side of the Irish Sea, but actually, throughout historic time it was dominated by the tribesmen of the Wicklow Hills. The presence of such a stronghold of hill people near Dublin was for very long a source of danger and difficulty to those who sought to establish authority over the whole of Ireland from its natural centre at Dublin. Thus as late as 1800 it was necessary to construct a military road to traverse the high moorlands from Dublin to the Aughrim Valley. Even to-day the one main road and railway which connects Dublin with the south-east of Ireland runs along the narrow coastland through the picturesque watering place of Bray; whilst the famous Round Tower of Glendalough remains there as a permanent reminder of the long held strongholds of early Christianity in the secluded valleys of the mountains.

(2) The Parallel Ranges and Valleys of the South-West

South-western Ireland is built up of a series of long, comparatively barren ridges of Old Red Sandstone trending roughly from east-north-east to west-south-west, separated by damp, fairly fertile valleys of Carboniferous Limestone covered by superficial deposits. The country thus owes its structure and relief to the Armorican series of earth movements. Whilst the hill ridges with their rough sheep pastures and the valleys with their damp cattle pastures and famous dairy herds form one natural twofold division of this part of Ireland, there is another which should be considered. There is the west, corresponding roughly with County Kerry, so cut off from the remainder of Ireland by ridges of mountains that it has been described, not inaptly, as a region under the title of the Munster Barrier. It is here that the wild mountains of Old Red Sandstone reach their greatest elevation, and where the intervening valleys pass seawards into long narrow arms of the sea known as rias,[1] in contra-distinction to fiords of different character and origin. To the east the mountains are less rugged and less wild, the valleys broader and of greater importance to the country as a whole. Here is part of the greatest dairying region in Ireland, with such important centres as Cork and Waterford, as well as an area devoted rather to feeding of cattle. Actually, dairying and feeding are commonly found on the same farm.

(*a*) The *Mountains of County Kerry and West Cork*.—This region really stretches from the wide estuary of the Shannon on the north to Bantry Bay on the south. The high mountain rampart which separates it from the remainder of southern Ireland on the east and south-east is lofty, bare or bog-encumbered country, intervening between the long valleys opening westwards to the Atlantic and the wide basins of the Lee and Blackwater, rivers draining eastwards and then south to the sea. Amongst the mountains of Kerry are the famous Macgillycuddy's Reeks, with the highest mountain in Ireland. In these peninsulas of the west the mountains occupy most of the country and support on their rough pastures numerous sheep, whilst the farms are smallholdings nestling in the hollows —a type of cottage farming comparable with the crofting of Scotland. The whole region is essentially a pastoral one, for cultivation is rare in Kerry, and even the fertile tracts are generally used for cattle rearing owing mainly to conditions of climate. Western Kerry has the heaviest annual rainfall for the whole of Ireland, the total in places actually exceeding 100 inches per annum. At the same time the climate is remarkably mild, especially in the winter months, when an average of over 44° is maintained, and a

[1] A ria becomes progressively deeper seawards; there is not the submerged lip so commonly found in the case of fiords and due to a moraine ridge.

mean January temperature of 46° is recorded in parts of western Kerry, being the highest figure for any area in the British Isles. The heavy moisture and excessive mildness of the climate is reflected in certain local features of the vegetation, rich in ferns and mosses, and even including plants proper to the western Mediterranean. Although to the west the force of winds from the Atlantic may prohibit tree growth, over restricted areas in the more sheltered valleys

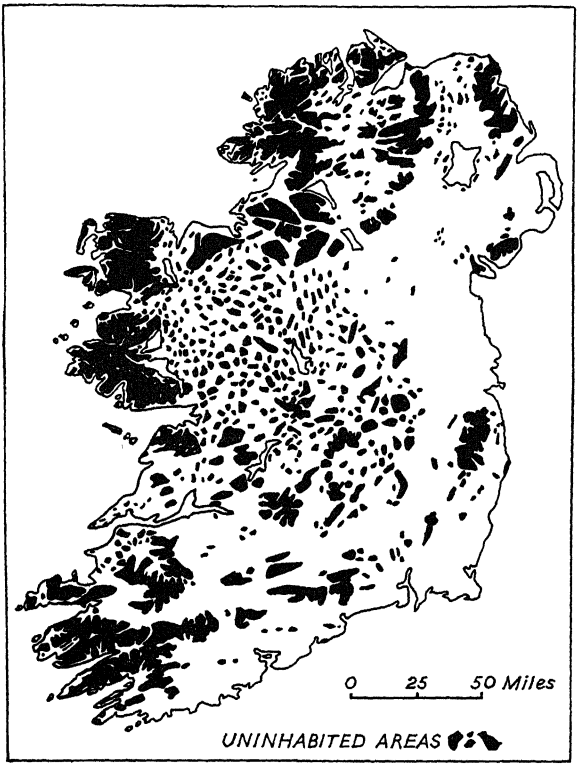

FIG. 298.—The uninhabited areas of Ireland

(From T. W. Freeman, Ireland, by permission of the author and Messrs. Methuen & Co Ltd.)

are the famous woods of Kerry, including in particular the strawberry tree (*Arbutus unedo*). Modern roads no longer leave this an isolated tract, and the wild country is much loved of visitors to Killarney. Previously the district was one of great isolation; the peasant communities of Kerry have remained detached from the main stream of economic, political and social affairs of Ireland. But much of the area is inhospitable and unsuitable to settlement, and the traditional capital of Munster (Cork) as well as its important towns are situated to the east of the barrier. It was only in times of stress that the

people naturally withdrew to their mountain fastnesses in the extreme south-west. Even the Viking invaders, used as they were to the mountainous conditions of Norway, preferred to leave this western side of Kerry; though they established settlements at Limerick and at Cork there does not seem to be evidence that they attempted a settlement here.

(*b*) The *Parallel Valleys of Cork and Waterford.*—This, the eastern half of the south-western region, has many of the advantages (such as mildness of climate and moisture to produce fine pastures) of the mountainous regions of Kerry, but is without its disadvantages. The drift-covered limestone lowlands afford some of the finest pasture in Ireland. The country to the south may be matched by that to the north in the famous Golden Vale of Limerick and Tipperary. This has thus become the greatest dairy-farming region of all Ireland. Turnips and potatoes are grown in the lowlands, oats are mainly restricted to the southern part in County Cork, whilst pigs, of course, are an important by-product of the dairying industry. It will be seen that in general the rivers and the river valleys have a trend eastwards, parallel to that of the mountain ridges. In succession from south to north one may notice the course of the Bandon River, the Lee, and the Blackwater, but the region is not as isolated from the Central Plain of Ireland as might be expected, because of the transverse valleys which interrupt the east–west mountains. An excellent example is that followed by the railway from Mallow to Cork, affording an easy line of movement between Cork and Limerick. In earlier days these routes were not as easy nor as practical as they are to-day; thus, although Limerick and Cork were settled by allied bands of Northmen, contact was closer between Cork and Waterford than between Cork and Limerick although the settlers in the two latter areas were originally more closely allied. Inter-communication between the farms in the valleys and the main centres has been an essential factor in the development of the co-operative dairy farming. In many parts 90 per cent. of the milk produced on the farms, notably in the county of Limerick, is dealt with in co-operative dairies, an indication of the high pitch of efficiency to which the industry has there been taken. In the east the important and fertile valley of the Suir, Nore, and Barrow focus on Waterford.

(3) The Mountains of the North-West

These mountains are built up of the same ancient metamorphic rocks as those which make up the Highlands of Scotland. The mountain rampart is exposed to the full force of the relentless waves of the Atlantic Ocean. There are innumerable rocky headlands and deep inlets overshadowed by barren rocky heights. In two places the waves of the ocean have penetrated the mountain rampart

as far as the fringes of the central lowlands. These two inlets are Clew Bay and the wider Donegal-Sligo Bay, and they have the effect of separating the mountain rampart into three parts: the mountains of Connemara in the south, the mountains of Mayo in the centre, and the mountains of Donegal or Tirconnail in the north. The first two are often linked together as the Connacht Highlands, whilst the latter is the north-western Highland properly speaking. The whole of this part of Ireland is exposed to the full force of the rain-bearing winds from the Atlantic Ocean. Large areas are so bleak as to be uninhabitable and tree growth is impossible. Extensive areas of the higher land were swept bare of soil during the great Ice Age, whilst between the barren mountains there

[*Photo: L. D. Stamp*

FIG. 299.—A typical "cabin" or peasant-proprietor's farm-house in the far west of Ireland

are huge glaciated surfaces, waterlogged and occupied by vast boggy moorlands which are again practically uninhabited. The population exists crowded together in the valleys and especially along the coast, and like the crofters of Scotland, the people live by carrying on subsistence farming. Sheep live on the better-drained slopes and furnish the wool for the famous Irish and Donegal tweeds. Potatoes are often almost the only crop possible, and there is frequently clear evidence of conscious and unconscious attempt of man and animal alike to seek shelter on the lee side of hills away from the full force of the Atlantic winds. In such situations are the little homesteads; here alone will trees grow.

(*a*) The *Mountains of Connemara.*—This region corresponds with the western third of Galway and the south-western corner of County Mayo. Running northwards from the town of Galway is the

Limestone belt which is described below as part of the fringe of the Central Lowlands. Westwards the junction between the often bare limestone surfaces and the ancient rocks of the highlands is usually quite sharp—so sharp that the line can often easily be drawn on a map. Actually along the junction there are frequently prosperous farms in wooded sheltered hollows; but away from this margin stretches mile after mile of almost uninhabited moorland. Shallow treacherous lakes occupy every hollow, and are in turn fringed by bogs; whilst between the lakes are extensive stretches of bare glaciated rock surface. Rounded mountain masses often practically bare of soil rise in lonely grandeur from the lake-studded lowlands. Their more fertile slopes may be covered by a moorland in which bracken and heather are important. Some of the scenic effects, such as the view of the Twelve Bens or Pins of Connemara seen from the south, are both majestic and awe-inspiring. Where the glaciated

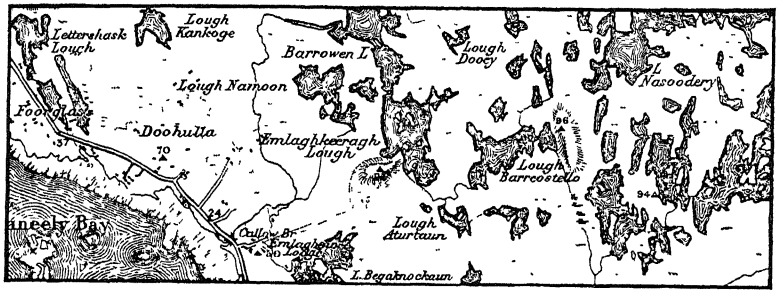

FIG. 300.—Part of the lake-studded lowland of Connemara

Note the restriction of settlements to the coast. Scale, 1 inch to 1 mile Reproduced from the Ordnance Survey map by permission

mountains reach the coast, the scenery again is often very fine, as in the fiord known as Killary Harbour. "Much of the sparse settlement in this region is along the coast, where fishing may be combined with subsistence farming, and where seaward drainage helps to improve the natural conditions. Little whitewashed single-storied thatched cabins lie scattered along the coast wherever a few fields sufficiently free from boulders may be secured. Frequently the little farm is situated on a slope with rough sheep pastures above and where hay, oats and potatoes may be grown on a narrow strip of land between the farm and the sea. A few small black cattle, an occasional pig and a few poultry form the rest of the live stock. Such is the character of the country around Clifden."[1] It should be noticed that in this far west even good pasture is scarce.

(*b*) The *Mountains of Mayo*.—These are broadly similar to the mountains of Connemara and Joyce's Country to the south of Clew

[1] L. D. Stamp: *An Agricultural Atlas of Ireland*, p. 60.

Bay. The width of the mountains of Mayo from north to south—that is from Clew Bay to the north—is roughly 30 miles, but only one road forces its way across them in this distance. The 57 square miles which make up Achill Island, the largest island off the Irish coast, consist almost entirely of wild moorland with only very occasional patches of cultivation. No districts in Ireland are more isolated from the main currents of national life than are these desolate tracts of western Galway and western Mayo. It is there, not unnaturally, that we find to-day the descendants of the earliest inhabitants of the island. Through the ages the sturdy hillsmen remained in defiance of foreign overlords coming there from across the plains to the east. To this day dark-skinned descendants of Neolithic man are to be found in the hill country of Galway and Mayo. This is, indeed, one of the remotest fringes of Europe. The railway has penetrated to the west coast at Clifden in Galway, but in Mayo has only succeeded in running along the northern shore of Clew Bay, and to obtain public conveyances northwards into the Mayo area is still difficult.

(*c*) *Donegal* or *Tirconnail.*[1]—In the wind-swept land of Conall the barrenness and rugged character of the Irish highlands reach their maximum, but though the coast is usually very broken and rock-bound the main mountain masses terminate abruptly before reaching the sea, there being usually a low, though narrow, coastal plain which makes possible the existence of a larger population in Donegal than in the bleaker, but less majestic, mountain country of Mayo and Galway. This is readily apparent in the maps showing the distribution of potatoes in the Irish Republic (Fig. 304), there being obviously more land under cultivation on the fringe of the Donegal mountains than in either of the preceding areas. This is true, for example, of the coastal fringe of the peninsula of Inishowen.[2] The climate is, of course, characterised by the prevalence of strong westerly and south-westerly winds, bringing a heavy annual rainfall, and by a mildness of temperature at all seasons. This is important. The absence of frost is marked particularly, and it is thus possible for the small cattle breeder of Donegal to allow his animals to remain in the fields even during the winter, at least in most years. The cattle thrive on the verdant pastures which are possible in many of the valleys, whilst on the hillsides are numerous sheep. Woodland is naturally absent in Donegal except on the sheltered, usually the eastern, sides of the hill slopes. On the east the mountainous massif of Donegal abuts against the broad, comparatively fertile, corridor which is formed in the main by the valley of the Foyle River and, by analogy with Scotland, may be called the Foyle Strath. Along it there now runs the boundary between the Irish Republic and Northern Ireland. The rugged mountain scenery of the north-

[1] Tir Chonaill = the Land of Conall.

[2] Inishowen = island of Owen.

western massif appears again to the east of the Foyle Strath in the Sperrin Mountains of Northern Ireland. The lowland basin of the Foyle has long been the focus of human activities. Strabane is one of the most important road centres of the country, and here the chief tributary of the River Foyle, the River Finn, joins the main stream. The east side of Donegal is far more fertile than the west: a light railway runs through this countryside to the town of Donegal and Killybegs. The natural centre for the Foyle basin is Londonderry, in Northern Ireland, hampered in its trade by the customs frontier so close to the town.

(4) **The Uplands of the North-East**

Lying in the counties of Cavan, Monaghan, and Louth is the continuation of the rolling country more fully described under Northern Ireland. Though the old rocks are largely masked by glacial deposits—this is part of the great drumlin belt—the drainage here is much better than in the plains of central Ireland to the south; bogs become infrequent or have been drained, but as in the neighbouring parts of Northern Ireland, there are rich pastures, more accessible than those amongst the bogs and so giving rise to a country where dairy cattle are important, and where there is an extensive cultivation of potatoes, as well as of oats, and in the drier east some barley and wheat. Pigs are numerous as a by-product of the dairy-farming industry; sheep are numerous on the drier pastures.

(5) **The Central Lowlands**

Now that the fringing highland masses of the Irish Free State have been described, there remains a great central region which is on the whole a lowland. It seems best to consider it as made up of four parts:

(*a*) The Central Plain properly speaking which is essentially a lowland with only low hills.

(*b*) The Western Fringe, where well-drained areas of glacial deposits and bare limestone tracts are commonly found.

(*c*) The Limestone Highlands of County Clare.

(*d*) The Southern Area, where great tongues of lowland are separated by hill masses, and where the fertile river valleys merge insensibly into the similar valleys of south-western Ireland.

These four divisions may now be considered in order.

The Central Plain.—On the ordinary solid geological map this tract appears as a broad sweep of Carboniferous Limestone, which extends also to the western fringe and far to the south. In the Central Plain, properly speaking, the limestone is, however, rarely seen. It is masked by a spread of glacial and later deposits. There

are wide areas of waterlogged boulder clay interrupted by infertile glacial sands and occasionally by loam. On a low-lying area of such a character, drainage is naturally bad. It is rendered worse by the presence of the limestone below, for water tends to pass through fissures in the limestone rather than across the surface by regular watercourses. The curse of the Central Plain is thus bad drainage and consequent formation of huge bogs. The Central Plain is

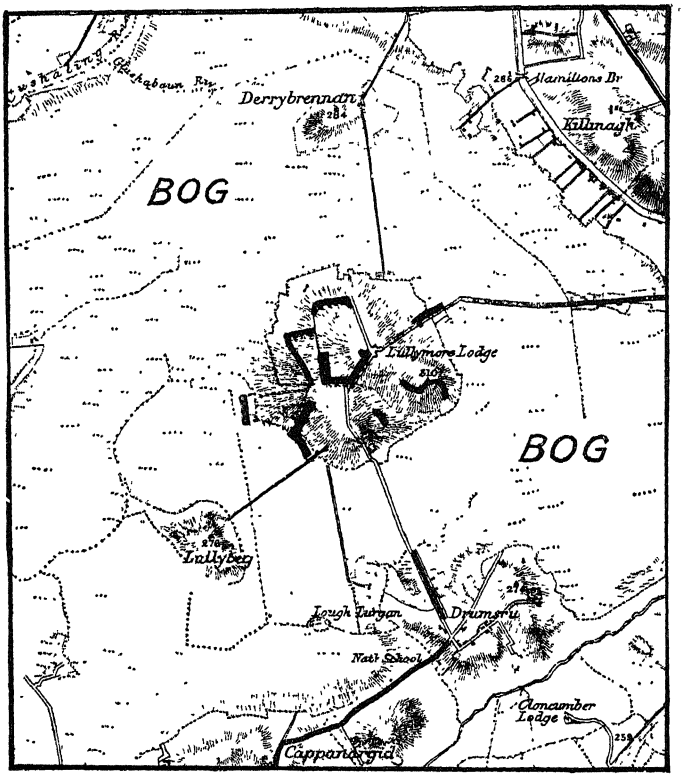

FIG. 301.—Part of the Central Plain of Ireland, in the region of the great bogs, showing "islands" of well-drained sands, very difficult of access, in waterlogged bogland. It is not surprising that Lullymore on this map has been abandoned as a farm

Scale, 1 inch to 1 mile Reproduced from the Ordnance Survey map by permission

thus the country of the great bogs for which Ireland is far famed. Away from the bogs it is a land of wet pastures where little cultivation is possible. The whole may indeed well be described as the Beef- and Bog-land of Ireland. Some of the larger bogs may be five, or even ten, miles across; and it is not infrequently a journey of several miles from a main road to an isolated farm. With such difficulties of communication it is obvious that dairy farming is

practically impossible. The regular collection of the milk for a central creamery would be out of the question. If dairy cattle are kept, as they are in small numbers, butter is made at the individual farms. On the other hand the damp pastures are, of course, excellent for cattle. Hence, as a map showing the distribution of beef cattle would indicate, there is an immense concentration of the stock-rearing industry on the Central Plain. Especially in the immediate hinterland of Dublin are there immense numbers ready for export to Britain. There is little cultivation of land, but the importance of potatoes relative to oats indicates the greater adaptability of potatoes as a food crop. In the south turnips become important—obviously grown as a cattle food. The Central Plain reaches the Irish Sea in the lowland stretch between the Wicklow Mountains on the south and the low hills of County Louth on the north.

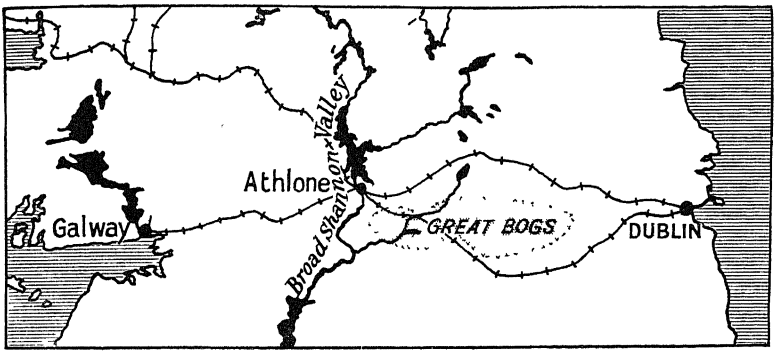

FIG 302.—The position of Athlone
A crossing place of the broad Shannon Valley

Here is the obvious gateway to the heart of Ireland, and the natural position for the capital. Notwithstanding the fact that Dublin is thus the natural port of entry, and the gateway into Ireland, communication across the Central Plain is not easy. It has been definitely facilitated, however, by the presence of ridges of glacial origin which pass more or less in an east–west direction across the Plain, and the old roadways followed these lines of sandy eskers or successfully skirt the bogs. There is one running almost directly westwards from Dublin as far as the west coast in Galway Bay (see Fig. 84). Even when the land of the great bogs has been traversed, there is the difficulty of crossing the wide marshy valley of the Shannon or the considerable bog-fringed lakes through which the river passes. Thus, naturally, the Shannon formed the boundary between the ancient kingdoms of Connacht on the west and Leinster on the east; whilst the position of the town of Athlone, where a crossing of the Shannon is rendered possible, is doubly emphasised

by its present-day importance as a railway junction and as a road centre. The esker ridges consist of roughly stratified sands and gravels, and are normally grass-covered. They are believed by some geologists to mark the courses of sub-glacial streams which were developed towards the close of the Ice Age, by others to mark periods of halt in the retreat of the glaciers. On some of the eskers and comparable mounds of glacial origin in the north and south of the main part of the Central Plain sheep are numerous. The importance of these glacial ridges is heightened during the heavy rains of autumn and winter when the subterranean waters, such a common feature of limestone country, rise in the neighbouring hollows, locally known as "turloughs," and convert them into shallow lakes. To the south-west of Dublin is the Kildare country—especially famous for its breeding of race-horses and Irish hunters. Even the wettest parts of the Central Plain—for example, the Shannon Basin—are actually at a considerable height above sea-level, and it is, of course, this fact which has made possible the development of the Shannon hydro-electric power scheme. Consequently, towards the eastern section of the Central Plain, where drainage to the sea is better, there are tracts much more favourable for the development of agriculture. Here the seasonal temperatures are the most extreme for Ireland, though even so the variation between average January and July mean temperatures is only about 20° F. The effect of prevailing westerly or south-westerly winds on vegetation is much less marked, and tree growth tends to be more abundant. On the other hand cold easterly and north-easterly winds in winter are able to penetrate a considerable distance into the central lowlands. Along the coastal fringe, the cultivation of barley, wheat, and potatoes is seen to assume a greater importance. It is a matter of the greatest significance that this better-drained land should be on the eastern side. The Central Plain has been in each epoch of invasion the home of the foreigner who has entered from the Irish Sea. The Vikings established their settlement in Dublin, and the port became the stronghold of the stranger just as it has been at many succeeding dates. The Anglo-Normans established in Dublin their outpost from England and their headquarters for the conquest of the wide Central Plain. Not unreasonably the holder of the port of Dublin would feel confident ultimately of establishing authority throughout the island, and at the same time ensuring protection to commerce in the Irish Sea by preventing raiders leaving *from* the natural gateway of the country. Although clansmen might remain virtually independent in the distant hills, the lord of the Central Plain was virtually the King of Ireland. This is, when one considers it, obvious, although at first sight remarkable in view of the by no means favourable conditions of the whole of the Central Plain.

The Western Fringe.—This seems a convenient designation for a

belt of country lying between the Central Plain properly speaking and the old mountains of the north-west. Actually it consists of two contrasted types of country. There are areas where the Carboniferous Limestone reaches the surface and gives rise to dry Limestone country covered with sparse sheep pastures, and other areas where the surface soils are of glacial origin but comprise comparatively well-drained mounds or drumlins and eskers. These mounds of sandy glacial material contain few boulders, so that stone is not available for the construction of stone walls. Instead the fields are divided by hedges. On the other hand the western position of the area and the dampness of the climate favour the growth of grass for hay, and the region is to be described therefore as a land of hay and hedges with oats, potatoes, and dairy cattle. In addition, especially in the north, there are outlying masses of the ancient metamorphic rocks of the highlands which stand up as

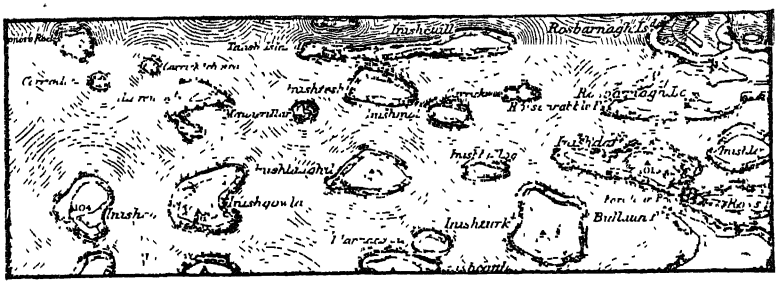

FIG. 303.—Clew Bay—an example of "drowned" country of drumlins
Scale, 1 inch to 1 mile Reproduced from the Ordnance Survey map by permission

hill ranges, particularly out of the limestone country. To consider the two types of land in somewhat greater detail, over considerable tracts the limestone may be almost bare, its grey-white surface seamed with solution channels, and supporting but little vegetation of any sort. This may be the case even on low ground, as to the north of Galway on the shores of Lough Corrib. Frequently the limestone is covered by patches of drift, and fades thus into the drumlin or esker type of country. The lower parts of the valleys near watercourses are often ill-drained and occupied by large bogs. The slopes are cultivated. The limestone blocks are used for the construction of walls, which become grassed over and divide the fields. Oats and other crops are largely grown; both cattle and sheep are numerous, though sheep are specially important. The farmhouses have an air of comparative prosperity, and this belt of mixed soils is obviously an important one. It is thus clearly incorrect that the country though hilly should be linked with the barren desolate tracts of the mountains of Connemara and Mayo by which

it is bordered on the west. The glacial country, on the other hand, is built up in the main of a series of drumlins or mounds of glacial material. It would require a map contoured at ten-foot intervals to show adequately its character. But where such country has been drowned, as in Clew Bay, the innumerable low islets give a clue to its general appearance. Near the sea the hollows are drowned, but elsewhere they are occupied by small scattered peat bogs, whilst reedy pastures occur on the more level stretches, the gentle slopes of the mounds being either occupied by cropped land or hay; whilst the driest slopes are given over to sheep. This type of country is well seen in the plains of Mayo or in the country round Clew Bay, or from Westport to Castlebar and Swineford. It stands out on the agricultural maps as the belt where the cultivation of oats and potatoes is important, and which has large numbers of cattle, sheep, and pigs. Where masses of the older rocks appear through the limestone or the cover of glacial deposits they give rise to mountains (of which the Ox Mountains may be quoted as an excellent example) forming a sort of outer rampart or bulwark of the Connaught (Connacht) Highlands against the Central Lowlands.

The Limestone Uplands of County Clare.—Here in the west is a typical limestone area, but one which has few glacial deposits. There are wide stretches of open grassy moorland comparatively free from peat, whilst flat-topped hills with abrupt edges, built up of almost horizontal limestone beds, break the monotony of the scenery. These limestone tracts are sparsely inhabited, and support mainly a limited number of sheep. Isolated tracts of a similar character occur fringing Sligo Bay near Sligo itself. In the southern part of County Clare are drift deposits which support pastures and share in the dairy-farming industry of County Limerick.

The Southern Area of the Central Plain.—This, perhaps, is the most difficult part of Ireland for which one may attempt to give a general description. The Central Plain with its great bogs passes southwards into an area where the plains are interrupted by numerous hills. Some of these are anticlinal masses where the older rocks—the Old Red Sandstone—are found outcropping from beneath the Carboniferous Limestone. Others, on the other hand, are synclinal areas where patches of Millstone Grit have been preserved in basins in the Carboniferous Limestone, but owing to their greater resistance to subaerial denudation stand up as hill masses. In the heart of the anticlinal hills of Old Red Sandstone still older rocks appear, and thus one gets barren rocky mountains with poor pasture, such as are found in Slieve Aughty, Slieve Bernagh, the Arra Mountains, Slievefelim, and Slieve Bloom. It will be noticed that in the neighbourhood of Killaloe on the Shannon, just to the north-east of Limerick, two of these masses of ancient rock approach close to the Shannon itself. It is here that the Shannon passes over the

rapids from Lough Derg (116 feet above sea-level) before reaching the town of Limerick, and it is the succession of rapids which has made possible the construction of the hydro-electric power works (see p. 105). Between the various hill masses there are broad tongues of lowland or corridors, which can be regarded as off-shoots from the Central Plain. These fade southwards into important

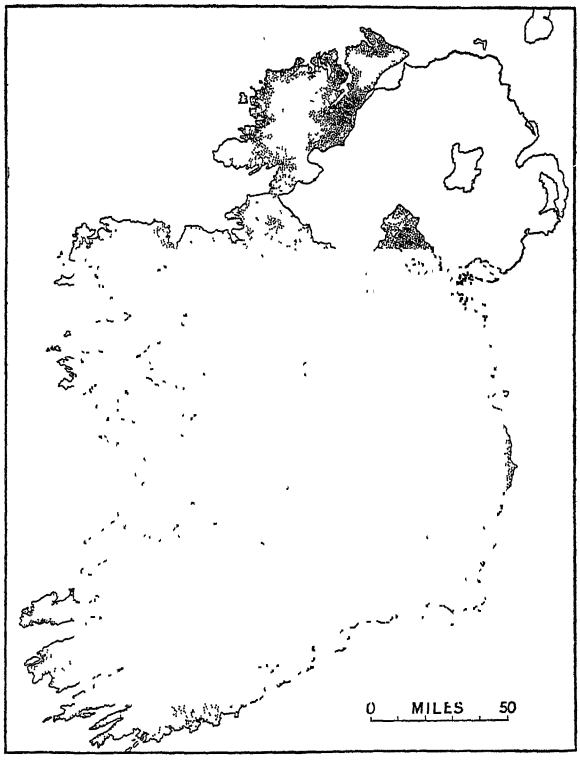

FIG. 304.—Map showing the distribution of potato cultivation in the Irish Republic

Each dot represents 25 acres

river valleys. Speaking generally, the valleys afford much cultivated land, especially on the slopes. Oats, potatoes, and turnips are grown. In the drier and more sheltered valleys farther to the south-east, barley becomes important. There are also very extensive cattle pastures, and the drier hill slopes above support numbers of sheep, whilst in the centre of the valleys themselves there are often extensive bogs. The easternmost of the larger valleys is that of the Barrow in which sugar-beet and mangolds are cultivated. The western part of the whole tract comes within the main dairying

belt of south-western Ireland, and it is here that the most famous, and perhaps the most fertile, part of Ireland—the Golden Vale of Limerick—lies between the region now under consideration and that which has been described under south-western Ireland. On the other hand the north-eastern portion of this varied tract is more closely allied with the Central Plain and, like the Central Plain, is famous for its beef cattle.

FIG. 305.—Map showing the distribution of sheep in the Irish Republic
Each dot represents 100 sheep

The Industries and Towns of Ireland

Many of the manufacturers of the Irish Republic are concerned primarily with the processing of home agricultural products. Of outstanding importance is the manufacture of butter and the dairying industry is organised essentially around the co-operatives which collect the milk and make the butter. With a relatively small home urban market there is not the demand for liquid milk which

characterises the dairying industry of England, Wales, and Scotland, and consequently the emphasis is on butter.

There is an associated cheese industry, though much less important. Mitchelstown, Co. Cork, is the main centre As far as the factory production of butter is concerned Cork continues to hold the dominant position, whilst the condensed milk trade is centred at Limerick.

An old established industry is that of bacon curing. There are bacon factories at the four chief towns—Dublin, Cork, Limerick, and Waterford—as well as in a number of provincial centres. Efforts have been made to spread bacon factories throughout the country in order to provide a convenient market for the pigs produced by the smaller farmers, but the pig population was temporarily reduced as a result of the scarcity of imported maize for feeding.

Centres of meat canning have also been established, notably at Dublin, Waterford, and Roscrea. The home production of sugar from sugar beet has been carefully fostered since 1925 and the output is about enough to supply home needs. There are four factories in the heart of the country at Carlow, Thurles, Mallow, and Tuam. Along with the growth of home production of sugar has been the development in the manufacture of jams and confectionery.

Although production of barley is not large, Irish barley has a high reputation as malting barley and goes largely to the breweries found in Dublin, Cork, and other towns, especially in the east. The most famous and the largest of the breweries is of course that of Guinness beside the River Liffey in Dublin. Irish whiskey is of course famous and distilleries are situated in Dublin, Cork, Tullamore, and Kilbeggan. Irish whiskey is quite distinct in character from Scotch and there is a considerable export market. There has long been a widespread appreciation of the dangers of alcoholism, especially from illegally home-produced spirits and the wide distribution of plants manufacturing soft drinks is an indication of the effects of the abstinence campaign.

Amongst other industries using agricultural products one finds naturally spinning, weaving, and dyeing of woollens, with a number of woollen mills as well as a large production of homespun cloths made by individual workers in the west. There are some famous mills near Cork, especially Blarney and Dripsey. Hosiery and knitwear are also to be noted, and the industry has spread to the making of clothes and a range of woollen rugs, blankets, and tweeds for export. A widespread leather industry and the manufacture of footwear reflects another use of home-produced raw material.

A group of industries is concerned to supply the needs of the farmers, notably with tools and agricultural implements and fertilisers. The milling industry is an interesting one. Some of the old mills still grind the wheat, oats, and barley supplied by farmers and return

the flour to them after grinding. The mills grinding imported wheat and maize have become important in the bigger towns. Limerick is now a milling centre.

Those industries making goods intended for the home market employ an increasing number of people but they tend to be concentrated particularly in and around Dublin, despite the Government's aim to spread industry widely. Paper and printing affords a

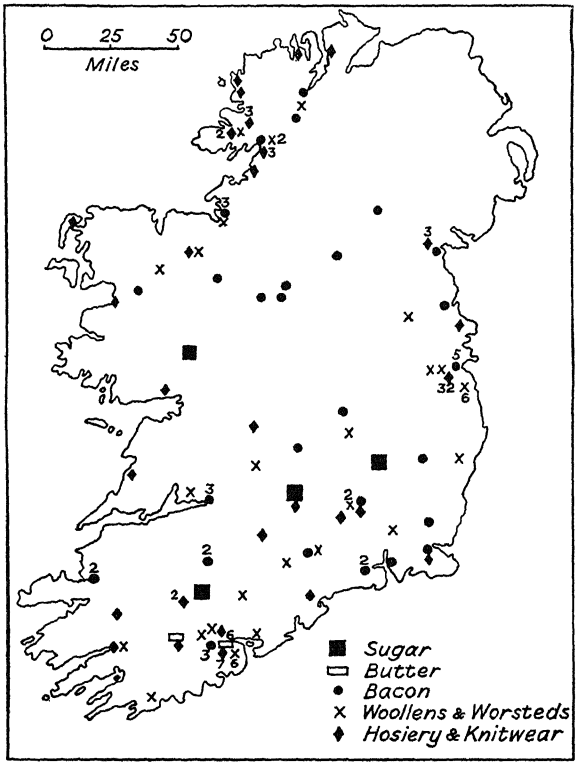

FIG. 306.—The Industries of the Irish Republic

Modified from T. W. Freeman, Ireland, by permission of the author and Messrs. Methuen & Co. Ltd.)

good example, whilst one of Dublin's largest factories makes biscuits and chocolate for distribution throughout the country. Other firms are concerned in Dublin, Dundalk, and Drogheda with tobacco manufacture. Engineering and metal works have also increased in importance, but it was not until 1938 that steel making was established in Ireland on an island in Cork harbour, a former British naval base with deep-water berths.

A description has already been given in an earlier chapter of the great Shannon hydro-electric power scheme from which electricity is

distributed over most of the country, though now providing only a fraction of national consumption. In view of the absence of coal, oil, and timber this water-power development has been of the greatest importance. The old staple Irish fuel was peat, never a very satisfactory one, although obtainable in many areas just for the labour of cutting and drying. Many isolated habitations and towns have gone direct from a peat age to an electric age.

The Ports of Ireland

The great bulk of shipping which serves the Irish Republic uses the port of Dublin, including its outport at Dún Laoghaire, formerly Kingstown, used by the regular service of mail steamers to Holyhead in Anglesey. Ocean liners, including trans-Atlantic, call at Cóbh, formerly Queenstown, and until recently at Galway, but in most cases normally receive and discharge their passengers by tender. Although there are many other small ports they serve mainly coastal traffic.

Dublin.—As regards its navigation, harbour facilities, and internal communications, Dublin is the obvious rival of Belfast, and is far and away the most important port of the Irish Republic. It handles the export trade with Scotland, the midlands and south of England. There are regular cargo or cargo-passenger services to Glasgow, Liverpool, Manchester, and by the relatively short sea route to Holyhead, with express connections therefrom on the other side, it occupies a central position as regards the transport system of the whole of Ireland. The Liffey on which Dublin stands is but a small river with a small catchment basin, but owing to the lack of gradient the channel in the estuary was formerly shallow and the deposition of sand continuous. Improvements have continually been made to provide deep-water berthage of at least 35 feet accommodating the large ocean freighters normally using the port. Larger vessels must wait for high tide to cross the bar over which there is 20 feet of water at low tides, thus enabling the port to be used by cross-channel steamers at all times. Constant and extensive dredging, however, will always be necessary. Above the loop-line railway bridge steam lighters come up to the breweries of Messrs. Guinness at St. James's.

The port is equipped for the bulk handling of oil and of various other commodities but side by side with modern methods of loading and off-loading may be seen numerous horse-carts and the handling of goods by hand-cranes. There is no direct passenger railway service in connection with the quays and this has developed traffic to Dún Laoghaire, which has direct rail connection. The port of Dublin itself, however, is so near to the heart of the city that the absence of rail facilities is no deterrent to passengers to Dublin itself, and there are several regular, but not daily, passenger sailings to ports in Great Britain, as well as the daily service to Liverpool.

The once-important Royal Canal is disused and the whole canal system which once linked Dublin with a large part of the heart of the island has become relatively unimportant, though the Grand

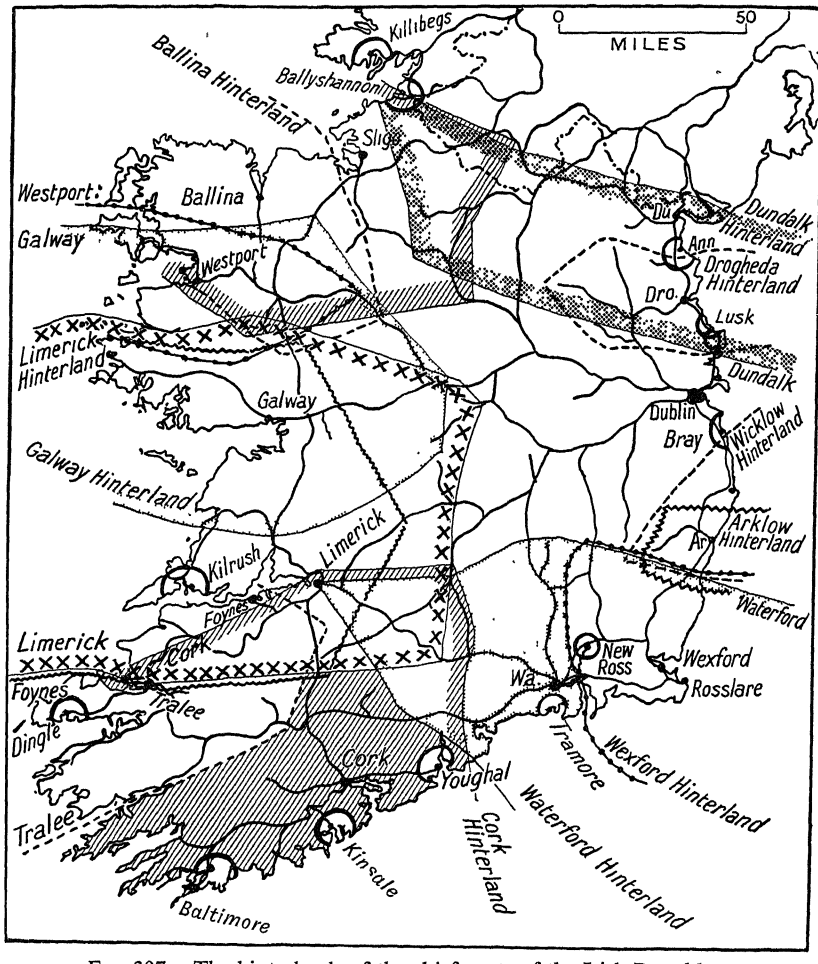

FIG. 307.—The hinterlands of the chief ports of the Irish Republic

The dotted area is exclusive to Waterford, the ruled area exclusive to Cork
Note that Dublin serves the whole of the Republic. (Map prepared by Dr Dora K. Smee relative to 1930)

Canal is still used. Nevertheless rail, road, and water place practically the whole of the Irish Republic in the hinterland of the port of Dublin.

In view of the absence of home production of coal there is everywhere throughout Ireland a demand for British coal in large quantities. Port and railways are still dependent upon it. Naturally

Dublin is still the chief importing port and it is to Dublin that are sent most of the manufactured goods for distribution throughout the Republic. As a collecting centre for commodities for export Dublin is also pre-eminent. More than a third of the exports of the Republic are live animals, cattle in particular, but also sheep and pigs. There is in addition the movement in both directions of race-horses and bloodstock and even greyhounds, which travel by air.

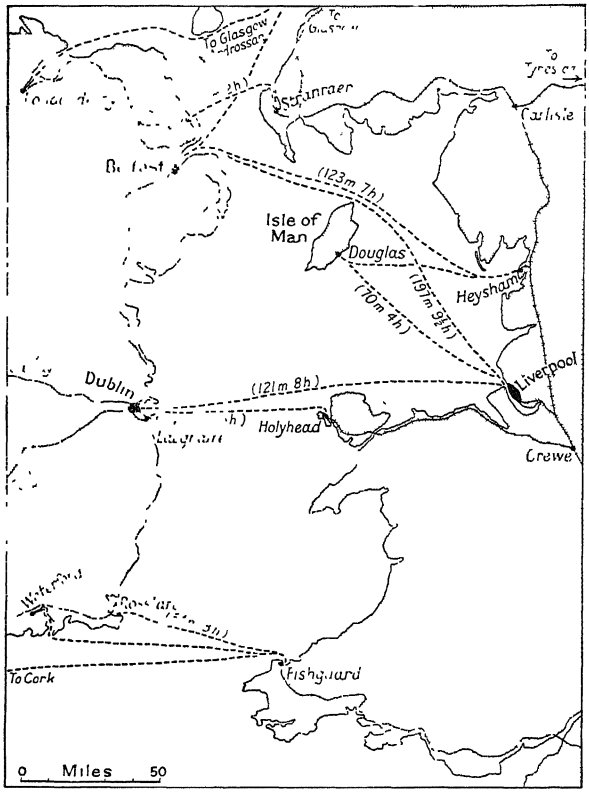

FIG. 308.—Links between Ireland and Britain

Live animals demand quick and efficient transport, hence the advantage in the situation of Dublin, only 61 miles from Holyhead and 121 miles from Birkenhead. Fat-stock rapidly loses condition and the time taken in crossing is very important, hence they are commonly sent to Holyhead and Birkenhead. Store cattle destined either for fattening or addition to the dairy herds of Britain are not so affected by a longer voyage and may go to other ports.

Though there is still a large export in stout and porter manufactured in Dublin the establishment by Messrs. Guinness of

breweries elsewhere, notably at Park Royal in the west of London, has considerably altered the position in recent years.

Most of the other exports from Ireland will be found passing

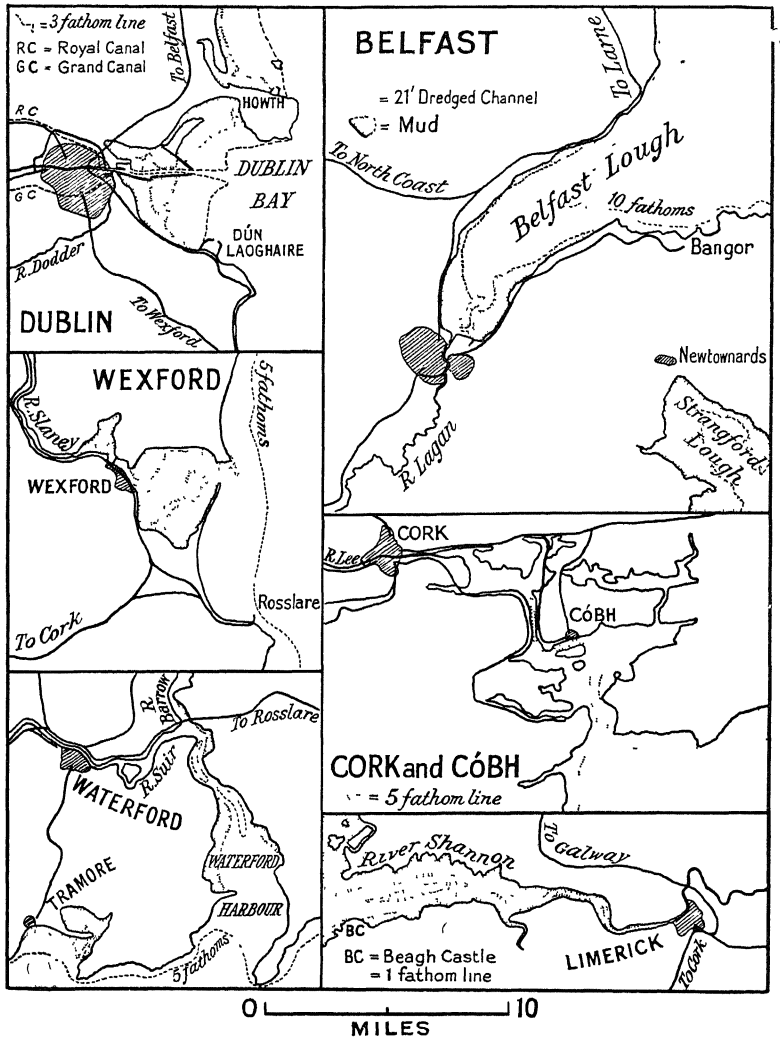

FIG. 309 —Sites of certain Irish Ports

through Dublin, which also handles a large part of the import traffic, less important than formerly, of feeding stuffs for animals. By contrast the coastwise traffic from Dublin is less important than from many of the smaller ports.

Although the harbour of Dún Laoghaire, or Kingstown, was built as long ago as 1817 as a refuge for vessels during south-easterly gales, it was developed as a result of interest of the railway companies into the premier passenger port of Ireland, favoured by the short distance from Holyhead in Anglesey on the Midland section of British Railways. Its old rival was Rosslare, in the south-east,

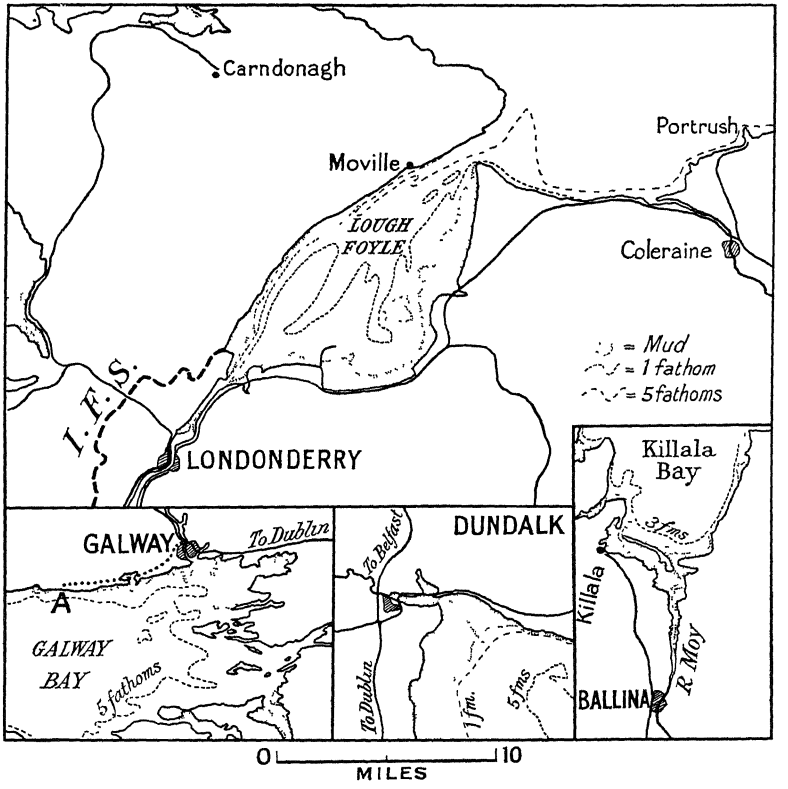

FIG. 310.—Sites of certain Irish ports

Galway: "A" is the site once proposed for an Atlantic terminal port, and the dotted line is the necessary rail link

with a service from Fishguard on the old Great Western Railway, now the Western Region of British Railways.

North of Dublin is the small port of *Dundalk*, importing coal, but more important is *Drogheda*, which has a considerable import of coal. The port, however, is poorly equipped and though small ocean vessels use the port cargo has to be unloaded by gangways and there are no direct rail facilities to the quayside.

Southwards from Dublin is the small port of *Wicklow*, importing a little coal, but more significant is *Arklow*, which was developed

as the Republic's largest fishing port. Like the other ports of the east coast, however, its significance has faded as Dublin's has been improved, but it imports china clay for a local pottery.

The small port of *Wexford* lies at the mouth of the Slaney and is served direct by railway, but more significant is *Rosslare* harbour, in reality an eastern continuation of Wexford where passenger and goods trains run alongside the vessels moored to the quay. Goods can be distributed with considerable facility to the south and south-west of Ireland. As a passenger port it has therefore long rivalled Dublin, to which it also occupies second place as a cargo port.

Though the sea passage is about the same as Holyhead–Dublin, the overall time of the journey from Cork to London via Rosslare is between two and three hours shorter than from Cork to London via Dún Laoghaire and Holyhead.

Along the south coast of Ireland the port of *Waterford* lies in a sheltered estuary where the combined Nore and Barrow are joined by the Suir. It is, however, only open to small ocean-going vessels at certain states of the tide, and the city and port of Waterford on the south side of the river are cut off from the railway on the other side. Formerly river traffic by barges inland was significant and at that time the port took a large share in the export of live animals.

Cork is the second port of the Irish Republic and the very large sheltered harbour includes the lower harbour of Cork itself as well as Cóbh or Queenstown situated on the south side of Great Island and with a quay adjacent to the railway station for reception of mails and passengers. The smaller trans-Atlantic liners can berth alongside. Other very small ports along the south coast include Kinsale, Baltimore, and Youghal.

Turning to the west coast of the Irish Republic exposure to westerly gales is a serious deterrent to the use of those ports which exist, which is unfortunate in view of the fact that Limerick at the head of the Shannon estuary, a tidal port for all vessels, includes the whole of the Shannon basin in its natural physical hinterland. Thirty-six miles from the open sea, on the south side of the estuary, is Foynes, which achieved a greater importance as a trans-Atlantic airport, was used both as a regular stopping place as well as for emergency landings when the airports of Britain were fogbound. It has been replaced by Eineanna or Shannon on the north side of the river.

Midway along the west coast, protected by the Aran Islands, is Galway Bay, a deep indentation reaching the plain of central Ireland. Unfortunately, however, the approach to Galway Harbour is not favourable to shipping because of the natural shelving which takes place and the existence of a ridge of hard rock crossing the

channel, which can only be blasted away, not dredged. There have been many proposals to develop Galway as a trans-Atlantic port, and for some years from about 1926, trans-Atlantic liners anchored in the roadstead a mile or so off the port and transferred their passengers by tender. In this way Galway was a port of call for

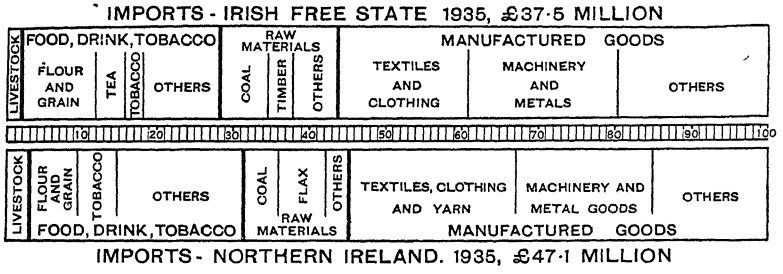

FIG. 311.—The Import Trade of the Irish Republic and Northern Ireland shown comparatively (for the year 1935)

FIG. 312.—The Export Trade of the Irish Republic and Northern Ireland shown comparatively (for the year 1935)

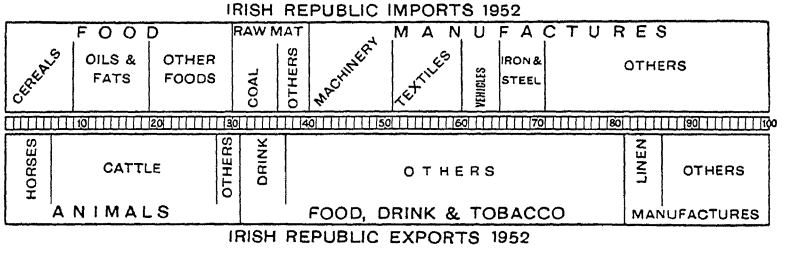

FIG. 313.—The Trade of the Irish Republic, 1952

passenger liners and, because liners call similarly now at Cóbh, it very frequently happens that Americans of Irish descent returning on visits to their relatives in Ireland land and never see either Britain or any of continental Europe.

There are other little ports on the west coast, such as Westport

and Ballina (on Donegal Bay), Sligo (on Sligo Bay), and Ballyshannon on the north-west side of Donegal Bay. They handle small imports of coal and other bulky commodities and are of no great significance.

The Foreign Trade of the Irish Republic

The diagrams illustrating the foreign trade of the Republic (Figs. 311–313) show at once the overwhelming importance of the exports of agricultural origin and stress the fact that latterly 40 per cent. of the value of the whole exports of the Irish Republic are formed by live animals—especially cattle. In this respect Ireland is unique, and to maintain this export it is clear that there must be an importing country near at hand. Actually, of course, the export of live cattle has been largely store cattle for fattening in the lowlands of England or of fat cattle ready for slaughtering when they reach Liverpool. Sheep and pigs are also exported live, whilst live animals also include bloodstock. Food and drink roughly equal live animals in value and include butter, bacon, eggs, poultry, and cheese. Beer and whiskey also form important exports. The imports into Ireland bring out the dependence of the country on foreign supplies of coal and most manufactured goods as well as the dependence of the country—as is true also of the United Kingdom—on foreign supplies of the essential foodstuffs. As we have shown elsewhere in this book, wheat used to be grown over large areas in Ireland, but one must admit that the geographical conditions of the country are quite unsuited to the production of this crop, and it cannot be grown economically in competition with other countries of the world where the geographical conditions are more suitable, as in Canada or Australia, though production is encouraged by Government.

There are, then, three special aspects of the foreign trade of the Irish Republic worthy of notice. In the first place, Ireland sells various commodities, particularly foodstuffs which are not produced in sufficient quantity in Britain, to that country; whilst Great Britain supplies manufactured articles that cannot be made in Ireland. It is not surprising, therefore, to see that the Republic in 1950 sold 75 per cent. of all its exports to Great Britain and a further 12 per cent. to Northern Ireland and purchased over 50 per cent. of all its requirements from the same sources. A feature of recent years has been the large import from the United States.

The second point is that in the supply of agricultural products to Britain, and indeed to any other country which may serve as a market for these goods, the Irish Republic has a great rival in Denmark. But in the third place the contrast with Denmark is interesting. Whereas Ireland's leading export is live cattle, Denmark specialises in butter and bacon. An interesting geographical comparison can be made between the Irish Republic and Denmark,

both countries hampered to some extent by natural geographical conditions—Ireland by too much rainfall and a poor drainage, and Denmark by a poor soil. Denmark has achieved success in her dairy-farming industry largely as the result of carefully planned co-operation amongst the small farmers. Ireland is treading the same path as far as her dairy-farming industry in the south-west is concerned. No geographical reasons really exist why Ireland should not attain the same success as Denmark has achieved.